The Engineer

MARCH 6, 1953 28, ESSEX ST., STRAND, LONDON, W.C.2 TWO SHILLINGS

UNIV. OF MICHIGAN
MAR 23 1953
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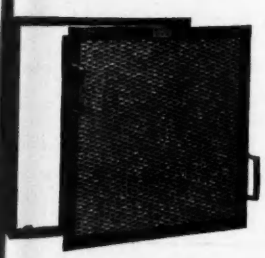

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THE ENGINEER

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NOTICE TO READERS

All letters intended for insertion in 'The Engineer' or containing questions should be accompanied by the name and address of the writer, not necessarily for publication, but as a proof of good faith. No notice whatever can be taken of anonymous communications. No undertaking can be given to return drawings or manuscripts; correspondents are therefore requested to keep copies.

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WORDING OF ADVERTISEMENTS: Approximately the first 25 letters of each advertisement are set in heavy type. Advertisers are therefore advised to begin their advertisements with the words they want emphasized.

Advertisements received by Mid-day Tuesday will appear in the issue of Friday the same week. Orders must be accompanied by a remittance.

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PUBLIC APPOINTMENTS

UNIVERSITY OF GLASGOW

DEPARTMENT OF CIVIL ENGINEERING

UNIVERSITY ASSISTANTSHIP

Applications are invited for a UNIVERSITY ASSISTANTSHIP in the Department of Civil Engineering. Salary scale £400–£550.

The appointment will be made according to the University Grading Scheme. The initial salary will be fixed according to qualifications and experience.

Applications (six copies) should be lodged not later than 21st March, 1953, with the undersigned, from whom further particulars may be obtained.

ROBT. T. HUTCHESON,
E7595 Secretary of University Court.

UNIVERSITY OF SYDNEY
AUSTRALIA

DEPARTMENT OF MINING

SENIOR LECTURER-IN-CHARGE

Applications are invited for the position of SENIOR LECTURER-IN-CHARGE in the Department of Mining.

The salary of the Senior Lecturer-in-Charge will be in the range of £A1050–£A1300 p.a., plus cost-of-living adjustment (at present £A239 males and £A182 females), with annual increments of £A50, and is subject to deductions under the State Superannuation Act. The commencing salary will be fixed according to qualifications and experience.

The successful applicant will be required to take up duties as soon as possible.

Further particulars and information as to the method of application should be obtained from the Secretary, Association of Universities of the British Commonwealth, 5, Gordon Square, London, W.C.1.

The closing date for the receipt of applications, in London and Australia, is 10th April, 1953. E7629

HUDDERSFIELD TECHNICAL COLLEGE
Principal : Dr. W. E. SCOTT, M.B.E.

CIVIL AND MECHANICAL ENGINEERING DEPARTMENT

LECTURERS

Applications are invited for the following posts :—

(a) LECTURER in the Civil and Mechanical Engineering Department. Applicants should be Graduates of a British University and preference will be given to those who have experience in teaching strength of materials and hydraulics to Final Degree standard.

(b) LECTURER in the Civil and Mechanical Engineering Department. Applicants should possess a Degree or equivalent qualification, should have had experience in industry and should preferably be Corporate Members of the Institution of Civil Engineers. The duties will involve the teaching of civil engineering subjects in day and evening classes up to the standard of B.Sc. (Eng.) and Higher National Diplomas and Certificates.

Salaries for the above posts will be in accordance with the Burnham Scales for Lecturers, viz., £940 by £25 to £1040.

Further particulars and forms of application may be obtained from the Principal, Technical College, Queen Street South, Huddersfield, to whom they should be returned as soon as possible.

H. KAY,
E7566 Chief Education Officer.

SURREY COUNTY COUNCIL

EDUCATION COMMITTEE
WIMBLEDON TECHNICAL COLLEGE
GLADSTONE ROAD, S.W.19

MECHANICAL ENGINEERING DEPARTMENT

SENIOR LECTURER

Applications are invited for the post of SENIOR LECTURER in the Mechanical Engineering Department. Preference will be given to Graduates with good industrial experience and some teaching experience who are prepared to do advanced work in Strength of Materials and Theory of Machines.

Salary in accordance with the Burnham Scale for Senior Lecturers in Technical Colleges : Men, £1040 by £25 to £1190 per annum ; Women, £832 by £20 to £952 per annum, plus London Allowance.

The successful candidate will be expected to commence duties on 1st September, 1953.

Details indicating the form of application may be obtained from the Principal, to whom completed applications should be sent within three weeks of the appearance of this advertisement. E7634

CITY OF CHESTER

COLLEGE OF FURTHER EDUCATION

HEAD OF TECHNICAL DEPARTMENT

HEAD of TECHNICAL DEPARTMENT required at College of Further Education, qualified to teach electrical and/or mechanical engineering subjects to Higher National Certificate standard.

Application forms and further particulars can be obtained from the Director of Education, Town Hall, Chester, to whom applications should be returned within fourteen days of the publication of this advertisement. E7591

MIDDLESEX COUNTY COUNCIL EDUCATION COMMITTEE

ACTON TECHNICAL COLLEGE, HIGH STREET, ACTON, W.3

HEAD OF THE MECHANICAL ENGINEERING DEPARTMENT

Applications are invited for the post of HEAD OF THE MECHANICAL ENGINEERING DEPARTMENT, to commence 1st September, 1953, earlier if possible.

Applicants should hold a good Degree in Engineering and have suitable teaching and industrial experience. The work of the Department includes courses for the B.Sc. Engineering Degree, Ordinary and Higher National Certificates, and National Diplomas in Engineering.

The Department is Grade III on the Burnham Technical Scale.

Salary scale : £1190 by increments of £25 to £1340, plus London allowance (£36 or £48 per annum).

Full particulars of the post and application forms may be obtained, by sending a stamped, addressed, foolscap envelope to the Chief Education Officer (F/CW/2), 10, Great George Street, Westminster, S.W.1, to whom completed forms should be returned within fourteen days of the appearance of this advertisement.

C. E. GURR,
E7610 Chief Education Officer.

THE COLLEGE OF AERONAUTICS

BOARD OF ENTRY

The Board of Entry of the College invites applications from suitable candidates for the TWO-YEAR COURSE, which begins in October, 1953, and ends in June, 1955.

Candidates should be of graduate standard, although the possession of a degree is not essential ; a good Higher National Certificate is an acceptable standard.

The College, a post-graduate institution, is devoted to the study of aeronautical science and engineering. The curriculum covers the five main subjects of aerodynamics, aircraft design, aircraft electrical engineering, aircraft propulsion and aircraft economics and production. Instruction in the first year is designed to provide students with a broad background of knowledge in all these subjects, with opportunity for limited specialisation in two or three of them. In the second year students specialise more particularly, usually in one subject.

Experiments in the air are an important part of the work, both in the first year, when all students take part in them, and in the second year, when they are linked to the specialist work of the departments.

Students who satisfactorily complete the course will receive the Diploma of the College.

Further particulars and details of the procedure for enrolment may be obtained on application to the Warden, The College of Aeronautics, Cranfield, Bletchley, Bucks. E7211

ROYAL CORPS OF NAVAL CONSTRUCTORS

ENTRY FROM PRIVATE SHIPYARDS AND UNIVERSITY

GRADUATES IN NAVAL ARCHITECTURE

A COMPETITIVE EXAMINATION for entry into the Royal Corps of Naval Constructors will be held in June, 1953. Accepted candidates will be entered as Probationers in the Royal Corps and will receive a course of training mainly at the Royal Naval College, Greenwich. Candidates must be not more than 26 years of age on 1st October, 1953, and (except for graduates) must have been engaged in practical shipbuilding for at least eighteen months before entry. Graduates of the Universities are preferred and in their case a period of practical experience of less than eighteen months may be accepted.

2. Full particulars may be obtained upon application to the Secretary of the Admiralty (C.E. Branch), Bath. Intending candidates must send to that address, before the 1st April, full particulars of their education and technical training, and of their practical experience.

PRIVATE STUDENTS OF NAVAL ARCHITECTURE

In conjunction with the above a QUALIFYING EXAMINATION will be held for Private Students who desire to take the same course as that prescribed for Officers of the Royal Corps of Naval Constructors under training. Candidates' applications should reach the Secretary of the Admiralty (C.E. Branch), Bath, before the 1st April. A fee of £50 per session is at present payable by private students taking this course, but the amount payable is under review. E7494

BRITISH ELECTRICITY AUTHORITY

(SOUTH WEST SCOTLAND DIVISION)

CHIEF GENERATION ENGINEER (OPERATION)

British Electricity Authority (South West Scotland Division) require a CHIEF GENERATION ENGINEER (OPERATION) at Divisional Headquarters, Glasgow. The commencing salary will be according to qualifications and experience, but will be within the existing range of £1575–£2000 per annum, which is provisional pending the negotiation of the permanent salary scale.

Applications, stating age, present position and salary, and giving full details of qualifications and experience, should be forwarded to D. Moffat, Director of Establishments, British Electricity House, Winsley Street, London, W.1, by March 23rd, 1953. Quote Reference AE/338. E7651

ELECTRICITY CORPORATION OF NIGERIA

CIVIL AND MECHANICAL ENGINEERS

The Electricity Corporation of Nigeria is the Electricity Supply Authority for Nigeria and has the following vacancies on its staff. Normal tours would be eighteen to twenty-four months. Several of the posts will be permanent, subject to a satisfactory probationary period of three years' service. Other posts are on contract terms and carry a gratuity instead of pension. The salaries shown are basic and carry, in addition, an expatriation allowance of £180 per annum on basic salaries up to £770, £240 on salaries from £771 to £1089, and £270 on salaries from £1090 to £1299. Salaries and allowances are paid monthly. Contract salaries are slightly higher and the gratuity is payable in a lump sum on termination of services. Accommodation will be available for every man appointed, usually in quarters furnished with hard furniture (for which a rental not exceeding 10 per cent of salary is charged). Medical fitness essential. First-class air fares out and home for officer and wife, with assisted passages or U.K. maintenance allowance for up to two children under 16. Liberal leave on full pay. Outfit allowance of £60 upon first appointment.

Forms of application and further particulars from the Liaison Officer, Electricity Corporation of Nigeria, 11, Manchester Square, London, W.1.

CIVIL ENGINEER, £660 by £40 to £1000 and by £50 to £1300 plus expatriation allowance. Corporate Membership of Inst. C.E. or Inst. Struct. E., with preference for work in design and drawing-office, although there would be some field work. Salary commencing at a point in scale commensurate with age, qualifications and experience.

MECHANICAL ENGINEERS (Grade III). Two appointments in the scale £830 by £30 to £950 plus expatriation allowance. Young men with National Certificates and Membership of the Institute of Marine Engineers with good practical training will be considered for these posts.

MECHANICAL ENGINEERS (Grade I). Two appointments in the scale £660 by £40 to £1000, thence by £50 to £1300 per annum, plus expatriation allowance. Starting point according to age, qualifications and experience. Essential qualifications are Corporate Membership I.Mech.E. plus sound knowledge and experience of steam-raising plant, turbo-generators and internal combustion engines.

MECHANICAL ENGINEERS (Grade II). Two appointments in the scale £985 by £35 to £1090 per annum, plus expatriation allowance, for thoroughly experienced men holding M/T First Class Certificate with diesel endorsement. E7586

WHITSTABLE URBAN DISTRICT COUNCIL

WHITSTABLE STORM WATER RELIEF

CONTRACT NO. 1

APPOINTMENT OF RESIDENT ENGINEER

Applications are invited for the above appointment, to supervise the construction at Whitstable of about 1100 yards of concrete pipe sewers, ranging in diameter from 12in. to 27in., of which about 460 yards are in heading, about 100 yards of 27in. diameter concrete sea outfall, and the conversion of a sewage pumping station to automatic control.

The work will be executed by contract and will be under the direction of the Consulting Engineers, Messrs. J. D. and D. M. Watson, MM.I.C.E., 18, Queen Anne's Gate, Westminster, S.W.1. The salary is £850 per annum, which includes £150 per annum to be considered as a lodging and subsistence allowance, which will not be subject to P.A.Y.E. deduction at source. The appointment, subject to satisfactory service, will last approximately two years and will be terminable by two months' notice in writing on either side.

Applicants, who should have had experience of similar work, should apply in writing to the undersigned not later than 27th March, 1953, giving full particulars of age, qualifications and experience, and enclose copies of not less than two testimonials.

A statement should be made by the applicant that he is not related to any member of the Council or staff and has not canvassed anyone in connection with the appointment.

F. TOMLINSON,
Clerk of the Council.

The Castle,
Whitstable,
February, 1953. E7542

HER MAJESTY'S COLONIAL SERVICE

PUBLIC WORKS AND RAILWAYS DEPARTMENTS

CIVIL ENGINEERS

Applications are invited for the following posts :—

Vacancies exist for experienced CIVIL ENGINEERS in the Public Works and Railways Departments, Gold Coast (CDE/112/13/04–5).

Consolidated salaries (including overseas pay) in following ranges :—Permanent and pensionable appointments in the Colonial Engineering Service, £1275 by seven annual increments to £1630 ; contract appointments in the Local Civil Service, £1600 by £60 to £2020, together with substantial gratuity on satisfactory completion of contract.

Minimum qualifications are : 28 years of age, a recognised University Degree or Diploma in Civil Engineering carrying exemption from Parts A and B of the A.M.I.C.E. examinations, seven years' approved practical experience.

Full details available on application.

Apply in writing to the Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, giving briefly age, qualifications and experience. Mention the reference number CDE/112/13/04–5. E7561

SUDAN GOVERNMENT

PUBLIC WORKS DEPARTMENT

ELECTRICAL SUPERINTENDENT

The Public Works Department, Sudan Government, requires an ELECTRICAL SUPERINTENDENT for service in the Sudan. He will initially be employed in the detailed planning and supervision of change-over, phasing out and so on of existing 2 and 3-wire D.C. system, including erection of O.H. lines, laying cables and liaison with contractors as required. Experience with B.T.H. and/or B.I.C.C. will be an advantage. Candidates should have had experience in a medium-sized undertaking employing high and low-voltage alternating current, experience in fault location, supervision of cable laying and erection of overhead lines. Experience in 11kV. cable joining and in change-over D.C. to A.C. would be a definite advantage. Age 25–35 years.

Appointment will be on probation for short-term contract (with bonus) for two years. Salary scale ranges from £E.750 to £E.1400. A starting rate of pay higher than the minimum, but not higher than £E.1050 is offered if justified by age, qualifications and experience. A variable cost-of-living allowance is now payable in the Sudan and is reviewed quarterly. No income tax is at present payable in the Sudan. Annual home leave on a generous scale after initial tour of approximately 18 months. Free passage by air both ways for official and family. Duty transport provided. Government accommodation, as available, provided at low rent. An outfit allowance of £E.50 is payable when contract is signed.

Further information and application form will be sent on receipt of a postcard only addressed to the Sudan Agent in London, Sudan House, Cleveland Row, London, S.W.1, quoting "Electrical Superintendent 1821," and name and address in block letters. E7623

MINISTRY OF SUPPLY

ATOMIC ENERGY RESEARCH ESTABLISHMENT, HARWELL

PRINCIPAL SCIENTIFIC OFFICER

The Civil Service Commissioners invite applications for one or more permanent and pensionable appointments. Candidates must have been born on or before 31st December, 1921. Required to take charge of small group engaged in problems of heat transfer and special problems arising in development of nuclear energy for power purposes, involving design of special experimental apparatus. Considerable opportunity for original work.

Candidates must have First or Second Class Honours Degree in Mechanical or Electrical Engineering or equivalent qualification, provided that a candidate without this qualification but of high professional attainments may be considered. Candidates must have had several years' experience in an engineering laboratory, with responsibility for experimental and development work.

Inclusive salary scales : men, £1033–£1377 ; women, £907–£1218. Starting salary determined by assessment of successful candidates' qualifications and experience.

Good housing prospects if married.

Further particulars and application forms from Civil Service Commission, Scientific Branch, Trinidad House, Old Burlington Street, London, W.1, quoting No. S4190/53. Application forms to be returned by 19th March, 1953. E7599

THE CEYLON FIRE INSURANCE ASSOCIATION

ASSISTANT INSPECTOR

The Ceylon Fire Insurance Association invites applications from junior engineers for the post of ASSISTANT INSPECTOR. Applicants should be about 30 years of age and unmarried. They must be technically qualified, holding not less than the Ordinary National Certificate in Electrical Engineering or its equivalent, and have received a comprehensive general engineering apprenticeship in the electrical/mechanical fields. Practical experience in the wiring of buildings for both power and lighting installations, together with a good working knowledge of the I.E.E. Wiring Regulations essential. Knowledge of sprinkler installations and ordinary fire protection equipment for buildings an advantage. The work is chiefly connected with the inspection and drafting of reports on the condition of electrical, mechanical and fire extinguishing equipment in factories.—Application forms and details of terms of engagement from the Secretary, Fire Officers' Committee (Foreign), 65, Watling Street, London, E.C.4. E1233

GREAT YARMOUTH WATERWORKS COMPANY

APPOINTMENT OF ENGINEERING ASSISTANT

Applications are invited for the post of ENGINEERING ASSISTANT at a salary of £735, rising by annual increments of £25 to a maximum of £885 per annum. The person appointed will be required to pass a medical examination and to contribute to the company's superannuation fund.

Applicants should be qualified civil engineers, experienced preferably in works of water supply.

Applications, giving full particulars of age, qualifications, training, experience (with dates), and the names of two persons to whom reference can be made, must reach the undersigned not later than 23rd March, 1953.

S. A. S. WALTON,
O.B.E., A.M.I.C.E., M.I.W.E.,
Engineer.

84, York Road,
Great Yarmouth,
26th February, 1953. E7596

THE ENGINEER

MARCH 6, 1953

Annual General Meeting of the Chamber of Shipping

ON Thursday of last week, the Chamber of Shipping of the United Kingdom held its seventy-sixth annual general meeting, at which Mr. D. F. Anderson was elected president. In his presidential address, Mr. Anderson said that two interrelated factors, namely, the domestic situation and our trading position in the outside world, governed our future. Taxation at home was dangerously high and while the industry could assist the body politic the amount of help should, he felt, be governed by the strength of the industry and not by those in receipt of help. So far the health of the industry had been relegated to second place, but Mr. Anderson affirmed that our shipping and the present level of taxation could not co-exist ; one or the other must decline, and it was evident that shipping had been the one to suffer. Taxation could only be eased by drastic cuts in Government spending, which meant, the president said, a changed policy with regard to the main channels of spending. To-day, while dry cargo tonnage was expanding and trade was contracting, Japan, Germany and Italy were steadily building up their fleets so that they would soon be back in the liner trades. Trading conditions had also deteriorated because of the existence of mercantile marines fostered by countries hitherto unimportant in the shipping industry. Trends in the industry were evident by the shipping returns, which, the president stated, showed that our tramp tonnage had fallen from 3·5 million tons in 1939, to 3·1 million in 1950, to 2·8 million in 1951, and had dropped to 2·4 million in 1952. Continuing, he mentioned that to maintain a fleet of 3,000,000 tons required an annual delivery of 120,000 tons of new ships, whereas 67,000 tons was the average for the last three years. However, one branch of shipping was expanding and that was the carriage of oil ; but, Mr. Anderson commented, from a national point of view, it was a pity that capital was being spent on something to be imported rather than on an export which could help to pay for food. Governments might be able to run ships at a loss, but the art of shipowning was to run them at a profit, for without profits, the president emphasised, it was impossible to replace old ships and, if that was not done, the British mercantile marine would continue to decline.

The Institution of Electrical Engineers

AT the annual dinner of the Institution of Electrical Engineers, on Thursday, February 26th, the toast of "The Institution" was proposed by Lord Cherwell, the Paymaster-General. Commenting on certain aspects of the high productivity of American industry, Lord Cherwell pointed out that the high value of horsepower per worker in the U.S.A. was largely due to the fact that American industrialists could retain sufficient profits to plough back into industry. Another point was that double-shift working in the U.S.A. shortened the life of machinery, so that it became economic to scrap it before it became obsolescent. He said that because of its importance to industry generally the electrical industry deserved every priority, in the provision of more recruits and better training facilities. Stressing the need for more technological institutions in Great Britain, Lord Cherwell said that Western Germany had no less than six Technische Hochschule. Finally he felt that electrical engineering was an exciting profession, for there was always something new round the corner. There was, for example, the possibility of releasing and using the free energy of coal by isothermal oxidation instead of employing the present wasteful combustion process. In his response to the toast, Colonel B. H. Leeson, president of the Institution, discussed some of the problems of training and educating newcomers to the industry at all levels from "the bench to the board." He accepted the value of technological institutions, but he thought that it was important for education to be broadly based and to embody those elements that were generally associated with life in a university. Referring to exports, Colonel Leeson pointed out that, whereas in the past the emphasis was on coal and cotton, the balance was changing and engineering now accounted for 53 per cent of Great Britain's exports. In this category the electrical industry was now not far behind the motor industry as an exporter.

Manchester Ship Canal Company

THE ninety-fifth ordinary general meeting of the Manchester Ship Canal Company was held on Friday last, under the chairmanship of Sir Leslie Roberts. In the course of his address, Sir Leslie dealt with various financial matters arising from the accounts and felt that the year's results were satisfactory. The replacement of assets and the modernisation of plant was a major preoccupation, which, he said, would remain so for many years. He mentioned that £3,250,000 had been spent on repairs to the fabric and on plant and equipment, while special maintenance would cost over £1,000,000 in the immediate future. Sir Leslie emphasised that, apart from making good the ravages of time, the company must adapt itself to changing requirements and instanced the growth of the oil industry. The oil dock at Eastham, which was expected to be opened before the end of the year, was under construction to meet the needs of this industry, which was mainly responsible for the rise in the tonnage using the canal. Continuing, the chairman had something to say about the high dredging costs caused by the considerable degree of silting up in the Mersey during recent years. In discussing the question of the quicker turnround of ships, Sir Leslie said that mechanisation was only part of the problem ; suitable manning was equally important, and he felt that recent agreements in this respect were a good augury for the future. While continuing to stress the importance of hard work, he said that the effort must be applied in the right direction, and believed that personal preoccupation did not make for happiness and was detrimental to economic progress. Great Britain was no longer a creditor nation and the old free flow of trade had been replaced by restricted imports, which affected the pattern of our export trade and also our ports and shipping. In the future we must look to the East for supplies and for our export markets, and Sir Leslie called attention to the need for port authorities to make the necessary adjustments to meet the new pattern of trade.

Lloyd's Register Launch Returns

THIS week Lloyd's Register of Shipping has issued its "Annual Summary of Merchant Ships Launched in the World During 1952," which includes ships of 100 tons gross and upwards. During the year 254 ships of 1,302,548 tons were launched in Great Britain and Northern Ireland, including 75 steamships of 448,510 tons and 179 motorships of 854,038 tons. The total is 38,476 tons less than that for 1951 and represents 29·6 per cent of the world output. Included in the returns are 3 ships of over 20,000 tons, all oil tankers ; 5 ships between 15,000 and 20,000 tons each ; 50 vessels between 10,000 and 15,000 tons each ; 13 ships of between 8000 and 10,000 tons ; and 57 ships between 4000 and 8000 tons each. Excluding ships of less than 1000 tons, the oil tankers launched amounted to 57 of 643,125 tons, made up of 17 steamships of 191,688 tons and 40 motorships of 451,437 tons, and represented a decrease of 190,809 tons compared with the previous year. Forty-five per cent of this tonnage is for registration abroad. Including ships of less than 1000 tons, the tanker tonnage represents 49·6 per cent of the total output for the year. Of the tonnage launched, 70 ships of 414,908 tons, or 31·8 per cent, are for registration abroad, of which 290,305 tons are oil tankers. Excluding China, Poland and Russia, the ships launched abroad totalled 820 of 3,093,030 tons, consisting of 161 steamships of 1,071,988 tons and 659 motorships of 2,021,042 tons, and represented an increase of 791,490 tons over 1951. A table lists the outputs of the individual countries and the names are given of 4 ships of over 20,000 tons. There were 20 ships of between 15,000 and 20,000 tons, 100 ships between 10,000 and 15,000 tons each, 36 vessels of between 8000 and 10,000 tons, and 106 ships between 4000 and 8000 tons each. Oil tankers of 1000 tons and over totalled 119 ships of 1,359,035 tons, consisting of 36 steamships of 507,715 tons and 83 motorships of 851,320 tons. They represented 43·9 per cent of the tonnage launched abroad, an increase of 655,209 tons over the previous year. Separate paragraphs give details of the launch totals of the leading countries abroad. The world total reached 4,395,578 tons, an increase of 753,014 tons over 1951, motorships representing 65 per cent of the world output compared with 75 per cent in 1951, and steamships burning oil totalling about 1,466,000 tons. Oil tankers of over 1000 tons totalled 176 ships of 2,002,160 tons plus 38 small tankers of 13,186 tons, representing 45·9 per cent of the world output. Of the world total, 485 ships of 2,757,753 tons, or 62·74 per cent, were being built under the survey of the Society.

American Aid for Industrial Productivity Schemes

LAST week there was published a White Paper setting out the arrangements for the expenditure of counterpart funds derived from United States economic aid under the Mutual Security Act of 1952. It states that the amount being made available from these counterpart funds is approximately £3,000,000. Under the general direction of the President of the Board of Trade, the money will be devoted, over a period of two to three years, to schemes associated with efforts to increase productivity. The Board of Trade says that such schemes will be designed "to assist in the provision of services by which industry can help itself, to promote research necessary for that purpose, to make provision to give industry encouragement to raise its efficiency, and to provide for co-operative action between Government, management and labour to enable industry to raise the national production to new heights." Details of the proposed allocation on these various forms of assistance mention an advisory service to deal with reorganisation problems and production techniques, the expansion of research into factors affecting the efficiency of the national economy, the promotion of studies in technological subjects at various universities and technical colleges, and loans to industry. On this last point the Board of Trade says that it is proposed to set up a revolving fund of £1,000,000 to be used for short-term loans to industry for the equipment and reorganisation of plant. This fund would be administered on terms which would provide that loans should be used to increase production and productivity. In the administration of the fund advice would be given by a committee or committees created for the purpose and including members selected from national organisations representing both sides of industry, such as the Federation of British Industries, the National Union of Manufacturers and the Trades Union Congress. The members would, however, serve as individuals and not as representatives of the bodies from which they were chosen.

Water Power in the Italian Alps

No. IV—(*Continued from page* 304, *February 27th*)

Following the introduction given to the Edison Group's hydro-electric schemes by last week's description of S. Giustina dam and Taio power station, we give below details of other developments owned by the Group. An example is given of the complete development of a catchment, and the " hollow " gravity dam design evolved by the Edison Company is discussed.

THE hydro-electric power stations operated by the Edison Group are so many and so varied that a description of only one or two examples of them can be given here.* The Group was very active in constructing new works in the years before the war and many of the installations date from the 1930s. However, a considerable volume of new work has been carried out since the war, as well as the repair of wartime damage.

The works in the Adige basin described last week constitute about 10 per cent of the Edison Group's total installed capacity; the remainder is situated to the west, in various tributaries within the catchment of the River Po. The most important series of developments is in the Toce basin, which lies to the north-west of Lake Maggiore (see Fig. 2 *ante*). The Upper Oglio (south-west of the Noce) is next in importance and the Group has further works on the Liro and the Mera and on the Brembo, tributaries of the Adda, as well as various less important areas of development in the central area of the Alps between the Toce and the Adige. There are also some power stations belonging to the Group in the Western Alps and the Apennines.

The Group also has steam power stations which until recently were generally obsolete, the most recent having been built in 1928. Large extensions are now being completed in the Genoa and Piacenza power stations, where four 62·5MW sets, purchased from the U.S.A. by E.R.P. funds, are being installed. The Group is also participating in the construction of the Tavazzano thermal power station near Milan. Last year, the two new 62·5MW sets at Genoa were completed, as was one similar set at Piacenza, bringing the Edison Group's total installed capacity to 276MW, for thermal power, including 25MW of the Tavazzano power station. As regards transmission lines, the Edison Group's network has been evolved to carry the power generated in the Alpine catchments to the centres of heavy load in Lombardy, East Piedmont, Liguria and Emilia. The principal lines are at present at 135kV, with others at 50kV and 70kV, but a number of main transmission lines at 220kV are planned, following, more or less, the general pattern of part of the existing 135kV lines. Some of these 220kV lines with a total circuit length of 828km, have already been built and are being operated temporarily at 135kV.

* Comprehensive details of the developments in each catchment are given in the volume *The Edison Group*, mentioned earlier.

Fig. 17—The Toce Basin

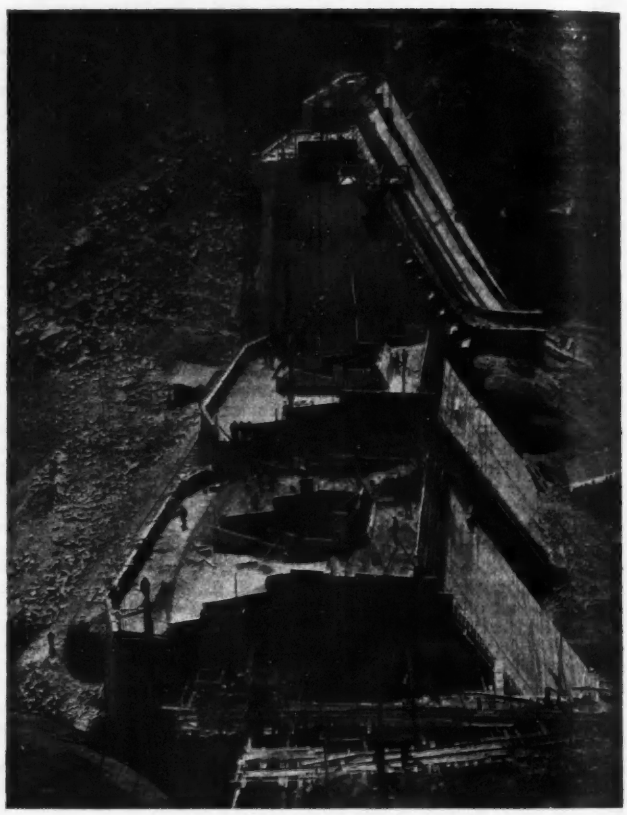

Fig. 18—Trona Dam Under Construction

The Toce Basin

One of the first examples of the substantially complete utilisation of the water power resources of an entire catchment has been provided by the developments along the Toce River, and its various tributaries. The area is shown in the accompanying map, Fig. 17. Between the altitudes of 7660ft and 730ft above sea level the utilisation of the Toce takes place through five successive heads; the tributaries of Devero, Diveria, Isorno, Ovesca, and other minor ones are almost wholly utilised. Many of the power stations have now been built and in operation for a considerable time, but some new works are in course of construction and others are proposed to complete certain gaps in the utilisation of the catchment or to modernise existing installations. The principal power stations have a total installed capacity of 431MW, with an average annual output of 1500 million kWh; the total storage capacity of the seasonal reservoir is equivalent to 409 million kWh.

The largest power station, the Motta power station, is at the head of the system. It has an installed capacity of 80MW; it was completed in 1933, with a capacity of 30MW, and was enlarged in 1938–39. It is supplied from three diversion systems leading from six different seasonal reservoirs, as may be observed from the map, under heads of 2899ft, 2836ft and 1558ft; provision exists for distributing water amongst these reservoirs to regulate their levels. The penstocks corresponding to the 2899ft and 2836ft heads arrive on opposite sides of the power station and meet in the same straight line to form a single penstock, with appropriate valves, parallel to the length of the machine room. Thus there are two operating heads at the power station, a lower one of 1558ft and a higher one varying between 2899ft and 2836ft and arranged so that either reservoir can be used to supply the Pelton wheels operating at the higher head. Discharge from the Motta station passes through a single turbo-alternator set in the Fondovalle

power station, which is remote controlled from Motta.

There are three horizontal Pelton wheel turbo-alternator sets in the Motta power station. One of them has a single Pelton wheel of 31MW, operating with the higher head, coupled to an alternator. The second and third sets each consist of two Pelton wheels, both mounted on the same side of the alternator and of 14·3MW and 16·8MW respectively, the alternator being of 33·3MVA. One of the Pelton wheels in each case is supplied from the penstock at the lower head and one from that at the higher. As was the practice at the time the Motta power station was built, the transformers and the switching station are built inside the power station building. The station is at the head of the 135kV line, passing down the valley on its route to the industrial centres further south, and has been used to supply reactive power at times of low load. At present a new outdoor transformer and switching station and transformer maintenance buildings are under construction, and a new 220kV line has been built to replace the 135kV line. Further work on this change-over is in progress at the Verampio power station, which is the controlling station for the transmission line and responsible for frequency regulation. There are two horizontal turbo-alternator sets in this power station, each consisting of two Pelton wheels driving a single alternator; these sets have just been renewed, ones giving the best characteristics for frequency regulations of the proposed 220kV line having been installed.

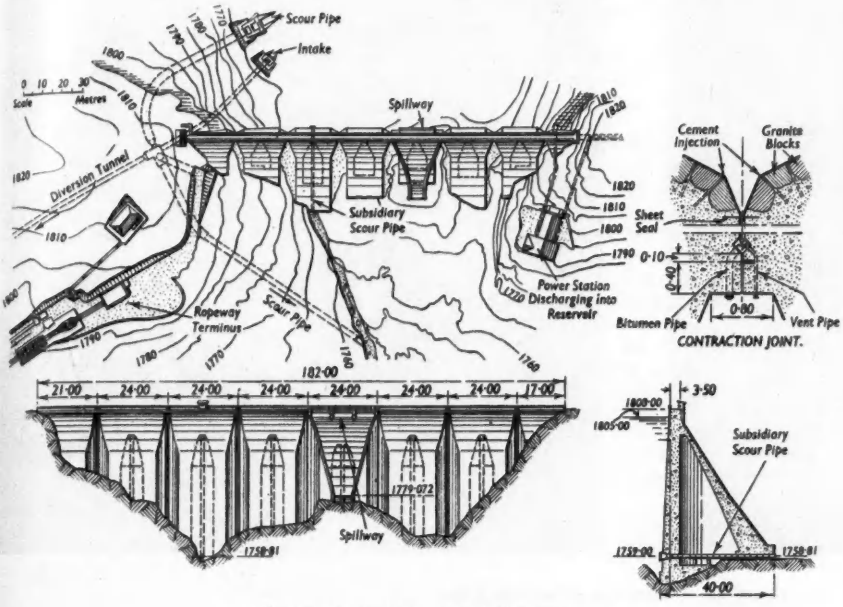

Fig. 19—Trona Dam on the Bitto River

Most of the reservoirs of this system are at high elevations, some higher than 7000ft, and much pioneer construction work at high altitudes was necessary at the time they were built. For the most part they are formed by gravity dams, some of which are of conventional concrete or masonry construction and cross section, but, as with some of the Edison Group's earlier reservoirs in other catchments, dry-jointed masonry gravity dams have been used in some cases. These dams are generally of massive cross section, often with stepped slopes on the upstream and downstream faces, and with an apron of concrete faced with stone blocks on the upstream face, to ensure water-tightness. The modern trend is to replace the gravity dam by the hollow gravity design evolved by Dott-Ing. Marcello, the Edison Company's chief civil engineer, which saves about 30 per cent of the volume of concrete required for an equivalent gravity structure. The first example of this construction in the Toce catchment is that of the Sabbione reservoir, which is at present under construction. It is the highest reservoir in the catchment and is of interest in that it is estimated that its capacity will be increased by the partial melting of the glacier which supplies it and over which it will encroach when filled.

The hollow gravity dam, it is claimed, presents several advantages common to the various different designs* which have been evolved to improve on the gravity dam. Uplift pressure is practically eliminated, the heat generated during the setting of the concrete is more easily dispersed, and there is considerable economy in construction. The percentage reduction in volume is almost equalled by the reduction in cost, for apparently the unit costs of "massive" and "hollow" gravity dams are almost equal, in the experience of the Edison Company, being only 1·5 per cent or 2 per cent in favour of the massive dam.

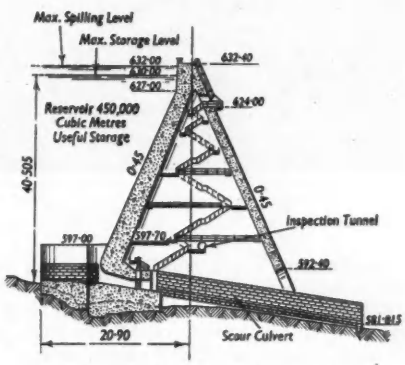

Fig. 21—Cross Section of the Poglia Dam

Examples of the hollow dam are shown in the various illlustrations herewith. In the early examples of this form of construction, such as the dam at Trona (Figs. 18–20) a cross section similar to a normal gravity dam, with the downstream face sloped, was adopted. A triangular cross section, as with the Poglia dam (Fig. 21), has, however, been used on later structures, as it gives a greater resistance to sliding. The Poglia dam is composed of a number of elements in a similar manner to that illustrated in the plan of the Trona dam. The volume of the Trona dam is 114,600 cubic yards and it forms a reservoir of 4210 acre-feet capacity at an elevation of nearly 6000ft above sea level in the Bitto catchment. The Poglia dam is in the Oglio catchment.

The earlier form of cross section of the Trona dam is brought out in the photograph, (Fig. 18), taken in 1941 whilst this dam was under construction. Three recent progress photographs of the Sabbione dam, which is mentioned above, are reproduced in Figs. 22–24. They were taken last September, towards the end of the working season at the high altitude—8070ft—of the dam site. It is estimated that, with the partial melting of the glacier mentioned above, this dam will form a reservoir of 27,240 acre-feet capacity. The glacier may be observed in Fig. 24. As may be seen from Fig. 17, the Sabbione dam is being built in conjunction with the Morasco power station, which will have an installed capacity of 44·7MW, a head of 2100ft and an

Fig. 20—Trona Dam

*Compare with Haweswater dam, *Journal* I.W.E., Vol. V, 1951.

Fig. 22 and 23—Construction of Sabbione Dam

annual output of 92,000,000 kWh, half of which will be winter power. Sabbione dam when completed, will have a maximum height of 61m, a base width of 54·74m, and a concrete volume of 135,000 cubic metres.

The Oglio and Adda Catchments

The Edison Group's plants in the Oglio catchment are not dissimilar in general layout and size to the more extensive developments on the Toce. Altogether, the Group's installed capacity in this area is 309MW, the average annual production is 1301 million kWh, and the storage capacity of the seasonal reservoir is equivalent to 317 million kWh.

The Adda River is one which is exceptionally favourable for hydro-electric development, and many concerns have built hydro-electric power stations in various parts of its catchment, but the Edison Group's interests are limited principally to its tributaries, the Bitto and the Liro-Mera. However, there are four low-head developments on the Adda itself, which are not without interest; they have a total installed capacity of 50MW and are capable of producing over 300 million kWh annually, with a particularly high number of hours of utilisation. The oldest of the four is the Paderno station, which was put into operation in 1898, as mentioned earlier, and the most recent is the Calusco station, which dates from 1925. The Paderno station is still radically unchanged.

On the Bitto River four successive heads totalling 6200ft were developed between 1939 and 1944. The third head of 1256ft is utilised by a Francis turbine—probably the highest head in Italy for this kind of turbine. The development of this valley was difficult on account of its narrowness, of frequent landslides, and of the high percentage of silt in the water. The hollow dam of the Trona reservoir forms part of this system.

Several schemes are under construction or in the design stages to complete the utilisation of the Liro and Mera rivers. They include a design for a reservoir of 160,000 acre-feet capacity, formed by a gravity dam with a volume of 2,500,000 cubic metres, 6300ft above sea level, which would serve a power station in Switzerland. The power station of S. Francesco, which was completed in 1927 to utilise a length of the Liro and its right-bank tributaries, is still the largest in the Edison Group's system. It has seven turbo-alternator sets, totalling about 130MW, which utilise a flow of about 848 cusecs under a head of nearly 2500ft, to produce about 380 million kWh annually. An interesting work which was completed about two years ago on the Mera River is that of the dam of Villa di Chiavena, which provides another example of the hollow design.

(To be continued)

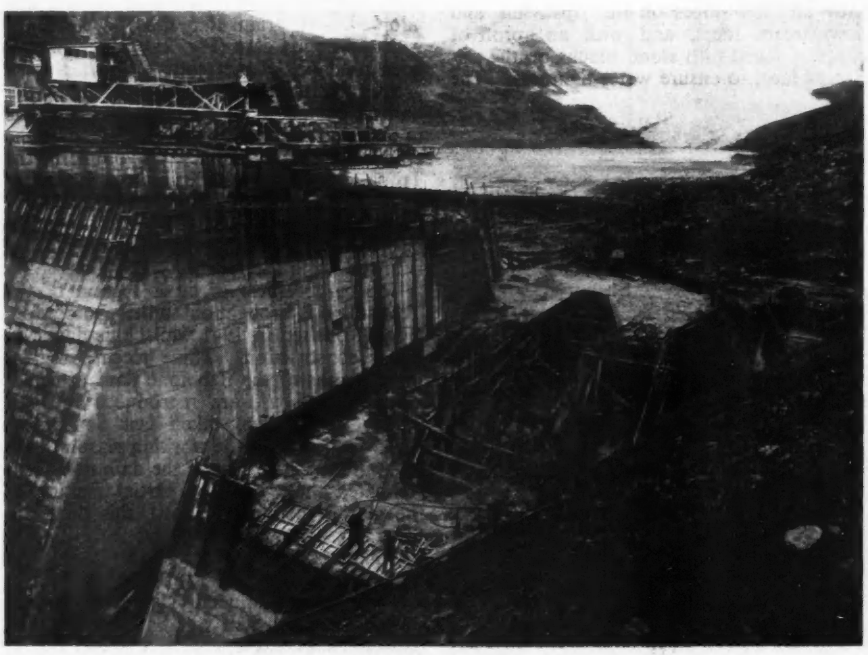

Fig. 24—Sabbione Dam Showing Reservoir Site

The Engineering, Marine and Welding Exhibition.—The organisers of the Engineering, Marine and Welding Exhibition—F. W. Bridges and Sons, Ltd., Grand Buildings, Trafalgar Square, London, W.C.2—have prepared a folder and reply card which they propose to send to buyers of engineering plant and equipment throughout the world inviting them to the exhibition, which is to be held from September 3rd to September 17th next at Olympia. In the hope that exhibitors themselves will find the folder useful for propaganda purposes, arrangements have been made to print a loose inset containing particulars of individual exhibits. A charge will be made for printing and supplying the insets and the folders.

The Testing of Concrete Mixers

By R. H. H. KIRKHAM, B.Sc., Ph.D., A.M.I.C.E.*

No. IV—A COMPARISON OF PERFORMANCE OF CONCRETE MIXERS

(*Concluded from page 323, February 27th*)

A commonly used mixer is the non-tilting machine, sometimes referred to as the free-fall or rotating-drum type, and it was considered desirable to compare its performance with that of the tilting-drum and open-pan mixers. Tests have thus been carried out to measure the efficiency of several mixers of these three kinds when mixing lean, dry concrete ; the capacities of the mixers were all less than ½ cubic yard.

Effect of Variations on Strength and Workability of Concrete

FROM the average values for the water/cement ratio given in Table V, and the limits given in Fig. 16, the average crushing strength of cubes twenty-eight days old made with normal Portland cement and the range of strength have been estimated from the known relationship between strength and water/cement ratio,[1] and are given in Table VI. The variations were larger than had been expected, since even with a good mixer the range was as high as ±450 lb per square inch, while, when the mixing action was less

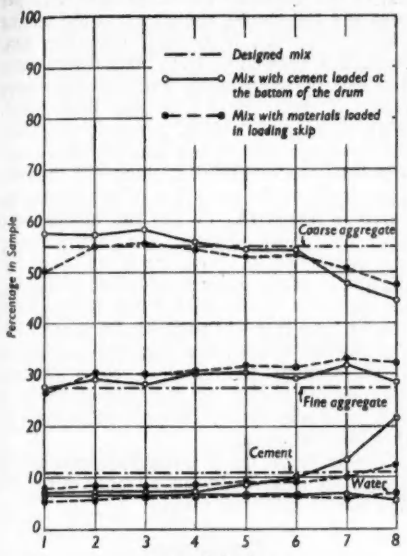

Fig. 17— Variation of Constituents in Eight Samples from Mixes in 7T Mixer

thorough, it was as much as ±700 lb per square inch. None of these theoretically-estimated variations could be attributed to variations in the quality of cement or in making or testing the specimens, but must have all been due to the mixing process.

It was considered of importance, therefore, to examine the effect of these variations on mix design. Neglecting the 2½ per cent of samples which may be expected to have a higher water/cement ratio, it would be reasonable to design a mix for hand-mixing with a water/cement ratio of 0·6 if the minimum strength permitted corresponded to a water/cement ratio of 0·625. If the minimum strength was specified to be greater than 4000 lb per square inch (which corresponds to a water/cement ratio of 0·61), the most optimistic estimate of the average water/cement ratio which should be used would be 0·61—(0·625—0·60)=0·585, since the slightly drier mix would be likely to lead to less uniformity.[2] For a mix of low workability suitable for use with the less powerful small vibrating screeds (compacting factor 0·85), this corresponds to an aggregate/cement ratio of 1 : 6·7, using an irregular gravel aggregate and 35 per cent of sand. In the same way, the necessary aggregate/cement ratio has been estimated for the seven mixers to give concrete of low workability with a minimum strength of 4000 lb per square inch, and is given in Table VII. In practice, the density of the concrete produced by these mixes between 1: 6·15 and 1 : 6·7 would be very similar and any reduction in the cement content can be regarded as the amount of cement which can be saved. Neglecting the 7 cubic foot pan mixer, if one of the more efficient machines (the 7 or 12NT or the 9 cubic foot pan mixer) is substituted for one of the less efficient (the 3½ or 7T or the 14NT) a saving of about 5 per cent of the cement used may, therefore, be made, and if the more efficient machines could be improved to give concrete as uniform as that thoroughly mixed by hand, a further saving of 2½ per cent in cement could be achieved.

Estimation of variations in workability is more difficult, since it is affected by the total aggregate to cement ratio and by the sand content as well as by the water/cement ratio, so that the limits in Fig. 16 *ante* cannot be used. The compacting factors for the average mix proportions given in Table V and for each sample, have been calculated approximately from the tables given in *Road Note*, No. 4,[1] and the average compacting factor and the range of workability for each mixer are also given in Table VI. Some of these variations were not as large as had been expected from the variations in the ratios determined by the test. For instance, the tests showed that the least uniform mixes in all respects were those from the 7 cubic foot pan mixer, but the average compacting factor was almost equal to the designed value and the range was not quite as large as that given by the 9 cubic foot pan mixer in which the proportions were some of the most uniform. This is owing to the interaction of the sand content, the water/cement ratio and the aggregate/cement ratio. An increase in water/cement ratio does not necessarily increase the workability, but may be compensated by an increase in the aggregate/cement ratio, and while there may be large variations in cement content between samples the workability may remain completely unaffected. For example, a mix of 1 : 6·2 with a water/cement ratio of 0·55 using a river gravel and 35 per cent of sand, gives low workability ; if 9 per cent of the cement is lost without the quantities of the other constituents being changed, the mix becomes 1 : 6·8/0·605, which is very similar to a mix of 1 : 6·9/0·6, which also has low workability. The large variations between batches in the 7 cubic foot pan mixer can, therefore, be attributed to variation in cement content which was probably the result of loss of cement on loading.

The results for the 7NT and the 12NT mixers also seem to be due, in part at any rate, to loss of cement. Although the workability was very uniform, it was low owing to the relatively high average gravel/cement ratios occurring at the same time as normal water/cement ratios. In order to avoid the reduction in workability due to those lean mixes, it would be necessary to increase the cement content by about 5 per

Table V—Average Mix Proportions and Variance Within and Between Batches

Type of mixer	Size, cubic feet	Water/cement ratio			Sand/cement ratio			Gravel/cement ratio		
		Mean	Standard deviation		Mean	Standard deviation		Mean	Standard deviation	
			Within batch	Between batches		Within batch	Between batches		Within batch	Between batches
Hand	3	0·604	0·0078	0·0084	2·48	0·038	0·025	5·06	0·168	Not significant
Tilting	3½	0·605	0·0270	0·0226	2·62	0·100	0·036	5·44	0·770	Not significant
	7	0·594	0·0305	0·0149	2·79	0·142	0·160	5·28	0·447	0·237
Non-tilting	7	0·603	0·0118	0·0167	2·55	0·046	0·101	6·75	0·475	Not significant
	12	0·598	0·0119	0·0196	2·65	0·058	0·116	5·87	0·418	Not significant
	14	0·620	0·0178	0·0172	2·59	0·097	0·071	5·44	0·484	0·218
Open-pan	7	0·668	0·0170	0·0657	2·65	0·102	0·271	6·14	0·420	1·030
	9	0·612	0·0154	0·0061	2·53	0·048	0·077	5·45	0·497	Not significant

Designed mix proportions 1 : 2½ : 5/0·60 by weight
All figures were calculated from the analysis of eight samples from each of five batches

Table VI—Estimated Effect on Concrete of Variations in the Proportions of Materials in the Mixers

Type and size of mixer	Crushing strength of cubes twenty-eight days old (pounds per square inch)		Compacting factor	
	Average	Variation	Average	Range
Hand mixed	4,100	±250	0·825	0·815 to 0·84
3½T	4,100	±700	0·805	0·785 to 0·86
7T	4,100	±700	0·79	0·77 to 0·84
7NT	4,100	±450	0·79	0·78 to 0·805
12NT...	4,100	±450	0·795	0·785 to 0·805
14NT...	3,850	±500	0·81	0·79 to 0·83
7 cubic foot pan	3,400	±1100	0·82	0·80 to 0·84
9 cubic foot pan	4,000	±300	0·815	0·795 to 0·84

Table VII—Estimated Mixes Required to give the Same Minimum Strength

Type and size of mixer	Maximum water/cement ratio recorded when designed ratio was 0·6	Average water/cement ratio required to get maximum > 0·61	Aggregate/cement ratio to give "Low" workability	Quantity of cement as percentage of total weight of concrete
Hand mixed	0·625	0·585	1 : 6·7	12·07
7NT	0·64	0·57	1 : 6·5	12·39
12NT...				
9 cubic foot pan				
3½T	0·665	0·545	1 : 6·15	13·06
7T				
14NT...	0·79	0·42	1 : 4·3	17·48
7 cubic foot pan				

* Road Research Laboratory.

cent for both these mixers. They were not less efficient than the tilting-drum or 14NT mixers, however, since although the workability of the concrete from these machines had a higher average value it was also more variable, and there was little difference in the minimum compacting factors. A similar increase in cement content would be necessary therefore to avoid unworkable patches. Even for the pan mixers, the minimum compacting factor was only a little higher and the cement content would have to be increased by at least 3 per cent to maintain the minimum workability required. It is interesting to note that when considering the water/cement, sand/cement and gravel/cement ratios, the 9 cubic foot pan mixer appeared to give the most uniform concrete, but that the variation in workability given by this mixer was actually greater than that given by any of the non-tilting type. It is important, therefore, to consider the strength and workability of the mix rather than the proportions.

Table VIII—Variation of Gravel/Cement Ratio in Concrete from Two Laboratory Pan Mixers

Mixer	Peripheral speed (feet per minute)		Samples from top half of batch				Samples from bottom half of batch			
			Edge of pan		Centre of pan		Edge of pan		Centre of pan	
	Drum	Mixing star	Average	Standard deviation	Average	Standard deviation	Average	Standard deviation	Average	Standard deviation
A	118	270	5·61	0·30	5·33	0·29	4·91	0·41	5·12	0·29
B	120	440	5·66	0·32	4·72	0·22	4·58	0·22	3·94	0·38

Designed gravel/cement ratio=5.
Results at edge of pan calculated from three samples from each of five batches.
Results at centre of pan calculated from one sample from each of five batches.

Examination of the Different Types of Mixer

It was considered desirable to examine the particular difficulties associated with each type of mixer as revealed by the tests.

NT Mixers.—While the effect of non-uniformity on the strength and workability of the concrete was being considered, it was noticed that the average gravel/cement ratios for two of the NT mixers were remarkably high. In the tests on the 7NT mixer as much as possible of the concrete remaining in the mixer drum was removed, and a sample was analysed as well as the eight samples taken from the discharge. The results of these analyses gave the average proportions of the material remaining in the drum to be 0·54, 2·57 and 4·27 for the water/cement, sand/cement and gravel/cement ratios, respectively.

Unfortunately, it was only possible to remove about one-third to one-half of the material from the drum without washing and the material remaining was mainly mortar stuck to the wrapper plate. The actual gravel/cement ratio would therefore have been much less. Assuming that the sample removed from the drum contained all the gravel remaining, the proportions of the whole batch were estimated using the results of the analyses, the weights of the discharged concrete and of the concrete sticking. The figures obtained were very similar to those of the designed mix and the variation in the average mix proportions can be attributed mainly to the incomplete discharge. This test is, of course, a severe one, since the amount of concrete "sticking" in the drum is generally greater for the first mix than for subsequent batches but it does indicate that "sticking" can lead to the discharged concrete having mix proportions much leaner than the designed mix. The poor and relatively slow discharge from this type of mixer must be regarded as one of its greatest drawbacks.

T Mixers.—The concrete produced by both tilting mixers was very variable, and in one test in which the drum was set with its axis about 5 deg. steeper than the correct mixing angle some segregation of sand was noticed after discharge. In order to investigate this point further, two tests were carried out on the 7T mixer with the drum loaded while stationary: in one of these the gravel was put at the back of the drum and the ratios were very similar to those when the loading skip was used; in the other the cement was put at the back and the variation of all three ratios was very large. The percentages of each constituent in the eight samples of this mix are shown in Fig. 17, together with those from one of the mixes which was loaded in the normal manner. The main variation for both mixes was in the quantity of cement, which was low for the samples at the beginning of the discharge, but increased rapidly towards the end, the difference being greater for the mix with the cement loaded at the back. The variability of the results was probably mainly due to a tendency for the fines to remain near the base of the drum, but it may also have been affected by a little cement sticking to the base. The total amount of sticking in this type of mixer, however, is much less than that in the non-tilting machines. This difficulty, of adequate front-to-back mixing, would probably be less pronounced with a wetter mix, but for dry mixes it appears to be a serious disadvantage.

Pan Mixers.—One of the pan mixers gave much more variable concrete than the other, and while considering the effect of lack of uniformity on the strength and workability of the concrete it was suggested that the large variations were due to loss of cement on loading. The pan mixer which gave very uniform concrete was not fitted with a power loader and the dry materials were loaded with the drum stationary. When this type of machine was fitted with a power loader, however, it was necessary to load the dry materials into the rotating pan before adding the water, since, if the water was loaded first, some of it was lost through the discharge door. This method results in considerable loss of cement as shown by the results of tests on the 7 cubic foot mixer and it seems probable that one of the main problems connected with the use of such mixers on civil engineering sites is the difficulty of loading.

An examination of possible reasons for the variability of the compacting factor of the concrete from this type was made using two small laboratory pan mixers. The water/cement and sand/cement ratios were very uniform, but the gravel/cement ratios were more variable; the results are given in Table VIII. Even when the speed of the mixing star was slow there was a significant difference between the amount of gravel at the top of the concrete and that at the bottom, and when the speed of the mixing star was increased the difference was increased. Increasing the speed of the mixing star also gave rise to differences in gravel content between samples taken from the middle of the pan and those taken from the edge. With this type of mixer, therefore, there is some tendency for the coarse aggregate to be thrown to the top and the side of the pan and never to be properly mixed with the mortar; increasing the speed of the mixing star in order to reduce mixing time increases this segregation.

Such mixers are also more likely to be affected by wear of the blades than either the tilting or non-tilting mixers. Before the first tests were made, the 7 cubic foot pan mixer had been in regular use for some time without any adjustment or overhaul. It was found that a considerable quantity of concrete was left in the pan after discharge (about 12 per cent of a full batch), showing that the mixing blades were not in contact with the pan. Inspection showed that the blades were worn and out of adjustment, and the tests were repeated after new blades had been fitted. With these new blades, properly adjusted, the discharge was very clean, and there was very little concrete left "sticking" in the pan. The results of the two series of tests are compared in Table IX. When the blades were worn and badly adjusted, the mixing action was completed in about the same time, but the quality of the concrete obtained was poor, the variation within each batch being much greater than that when the blades were new. For efficient use of these machines, therefore, it is essential to maintain close contact between the blades and the base of the pan, and the blades should be renewed as soon as they become worn.

The tests on the 7 cubic foot pan mixer previously described were all made after the new blades had been fitted.

Conclusions

The tests have shown that none of the three types of mixer tested was perfectly suitable for mixing "dry" concrete. The difficulties associated with each type were not the same, but they gave rise in them all to larger variations in the strength and workability of the concrete than those when the concrete was thoroughly mixed by hand.

Although there were differences between mixers of the same type, the tests have indicated differences which can be attributed to the type of machine. In general, the non-tilting machines seem likely to produce the most uniform dry concrete under site conditions at the present time, and the pan mixers to give quicker mixing. The non-tilting

Table IX—Effect of Wear of Blades in 7 cubic foot Pan Mixer

Condition of blades	Water/cement ratio			Sand/cement ratio			Gravel/cement ratio		
	Mean	Standard deviation		Mean	Standard deviation		Mean	Standard deviation	
		Within batch	Between batches		Within batch	Between batches		Within batch	Between batches
New...	0·668	0·0170	0·0657	2·65	0·102	0·271	6·14	0·420	1·030
Old and badly adjusted	0·677	0·0670	0·0620	2·58	0·322	0·308	5·75	0·862	0·421

Designed mix proportions 1 : 2½ : 5/0·60 by weight.
All figures calculated from the analysis of eight samples from each of five batches.

machines gave concrete of fairly uniform strength and workability, but the average workability was lower than that intended. This has been attributed to the slow and incomplete discharge of this type. The strength and workability of the concrete from the tilting-drum mixers was more variable, probably owing to the tendency for "fines" to remain near the base of the drum, and for them not to be properly mixed with the remaining material. The pan mixers gave concrete of only moderately uniform workability, but of fairly uniform strength when they were loaded with the drum stationary, but when a power loader was used the variations in the strength increased considerably. This increase in variation was considered to be due to loss of cement on loading which is one of the main difficulties with this type. There was also a tendency for the coarse aggregate to be thrown to the top and sides of the pan, particularly when the speed of the mixing star was increased to get quicker mixing; this segregation may persist during discharge. It was noticed as well that wear of the blades in these mixers may lead to large variations and they require careful maintenance.

An estimate of the effect of the variations observed on the design of the mix, has shown that the substitution of a more efficient mixer might lead to a saving of up to 5 per cent in cement, where one of the less efficient machines was being used. Improvements in the machines might be expected to lead to a further saving of about 5 per cent of the cement required.

ACKNOWLEDGMENTS

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REFERENCES

[1] Road Research Laboratory, "Design of Concrete Mixes" *Department of Scientific and Industrial Research, Road Note No. 4*, London, 1947: H.M. Stationery Office.
[2] Kirkham, R. H. H., "The Testing of Concrete Mixers, Part II: Effect of the Materials Used and the Mix Proportions." (p. 286-288 *ante*)

The Safety Factor in Construction

By F. C. THOMPSON, D.Met., M.Sc.*

In the Second Cantor Lecture before the Royal Society of Arts, of which we print an abridgment below, the author discusses the methods by which the strength and other properties of metals could be improved. He suggests that engineers may be asking for unnecessarily high degrees of ductility and toughness and points out that if material of lower ductility and toughness were acceptable metallurgists could provide materials, still very far from brittle and with greatly increased yield strength. The lecture was read on March 2nd.

THE factor of safety to be employed in any given structure is a matter for the engineer alone. Any attempt by the metallurgist to override the results of experience would be presumptuous, and I have no intention of entering into this field. Where the metallurgist can be helpful, however, is by indicating possible sources of increased strength in engineering materials and therefore, without any modification of such factor of safety as the engineer may deem necessary, to obtain the given strength in the structure with smaller sections and therefore with economy in material. This is what I hope to attempt this evening.

Improvements in the mechanical properties of steel may be effected by changes of composition, or of heat—or mechanical treatment, and these will be considered in turn.

Improvement by Chemical Means

It is a curious fact, and one which seems to be a general phenomenon in metallurgy, that a greater hardening effect is obtained when small proportions of a large number of different elements are dissolved than when the same total amount, even of the most efficient of these, passes into solution. The high-tensile gold alloys and the complex steels used for tools or for high temperature service illustrate this fact equally. So far, then, as ordinary steels are concerned, it would appear that a very large field of investigation, at the present time inadequately explored, is that of the simultaneous addition of many elements, nickel, chromium, vanadium, copper, molybdenum, aluminium, &c., all in small amounts, of the order of a fraction of a per cent. The simultaneous effects of hydrogen, nitrogen and boron in even smaller amounts could well go side by side. In this connection it may be noted that as time goes on the tendency for the average steel to contain greater and greater percentages of "residual" elements increases, and the time has already come when it would repay much work and trouble to inquire how far these, instead of their being regarded merely as nuisances, can be turned to good account in raising the strength of the everyday steels.

As the carbon content of an unhardened steel increases so, of course, do the elastic limit and the tensile strength. Simultaneously the ductility tends to fall. Where the material is to be subjected to service under stresses which are essentially static, the question inevitably arises as to whether the steels employed at the present time are not of unnecessarily low carbon content; in other words, whether it is necessary for the engineer to insist on such high values of the elongation per cent and reduction of area as he does at the moment. This is clearly a matter for the engineer himself to decide, but if he could satisfy himself that, at any rate in many cases, existing specifications do demand a higher ductility than is in fact necessary, higher carbon steels, of increased strength, could be employed, and a corresponding saving in the tonnage used be effected.

Even with a carbon content as high as 0·45 per cent, together with a manganese content of 0·78 per cent, 1¼in diameter bars normalised at 870 deg. Cent. give the following test figures:—

Yield point	27 tons per square inch
Maximum stress	44 tons per square inch
Elongation per cent on 2in	27
Reduction of area	54 per cent
With an Izod value of	31ft-lb

It is difficult to believe that such a steel does not possess both a sufficient ductility and adequate toughness for most normal constructional requirements. Such higher carbon steels might present somewhat greater difficulties in production and manipulation, but these are not insuperable if the increase strength is deemed justifiable.

The time, too, has surely come when the question of the reliability of the higher manganese steels should be settled once and for all. There is sometimes a feeling that such steels, with a manganese content between perhaps 1½-2 per cent are "uncertain," but the evidence for this is by no means conclusive. May I quote here at length from Bullens' well-known book: "It has been difficult for the carbon-manganese structural steels to live down their previous bad name for being 'brittle.' The author has not changed his opinion, expressed in the previous edition of this book, that the carbon-manganese steels are *not* brittle. In fact, he now believes it logical to eliminate (even) the word 'sensitive,' then applied. With proper control of heating, forging and finishing temperatures, and saturation on heating for hardening, followed by a rate of cooling denoted by carbon-manganese content in relation to the mass-surface factors, these steels are no more sensitive than the other alloy structural steels, and, in fact, less sensitive than some." "The evidence at hand to date warrants the statement that, for many structural and engineering purposes, these carbon-manganese steels are vastly superior to carbon steels . . . and they are equal to, or better than, many low alloy steels." "Normalised carbon-manganese steels are better than normalised chromium-molybdenum steels." But "it is not to be inferred from the above that the carbon-manganese steel is the 'one, all-purpose' steel, for such is not the case; but it is a low-price steel suitable for many purposes and its value is not generally recognised."

Typical figures for steel containing 0·3 per cent carbon and about 1·6 per cent manganese, normalised at 900 deg. Cent. and tempered at 400 deg. Cent., even in the as-cast condition, were as follows:—

Yield point	29 tons per square inch
Maximum stress	45 tons per square inch
Elongation per cent on 2in	20
Reduction of area	39 per cent
With an Izod value of	39ft-lb

There is nothing here to suggest anything dangerous. Such a test, in fact, suggests a material of thoroughly good properties.

Such steels in the higher manganese range are of higher hardenability than those at present normally employed, and certain modifications in practice may be required, but these modifications, if required, could be made without any undue difficulty.

TABLE I—*Effect of Phosphorus on the Tensile Properties of a 0·3 per cent Carbon Steel, as Rolled (Stead)*

Phosphorus per cent	Yield point, tons per sq in	Maximum stress, tons per sq in	Elongation per cent on 2in	Reduction of area, per cent
0·04	20	33	23	52
0·3	25	40	23	45
0·5	32	44	20	45

Another and very much more controversial question arises with regard to the phosphorus content to be permitted. That the yield point and tensile strength of a mild medium carbon steel in the unhardened state increase with the phosphorus is well known (Table I). That the ductility falls, but at no particularly alarming rate, has been shown by Stead so far as straightforward tensile properties are concerned. There is, however, the belief, for which a considerable body of evidence exists, that steels of high phosphorus content may fail by brittle fracture when subject to shock, and that such steels are inherently "wicked." A good deal of work has been done on the effect of phosphorus, particularly on low carbon material. Micrographically it results in the grain size becoming coarser for a given heat-treatment and along with this an increased tendency for brittle, cleavage

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fracture. There are, however, other elements, aluminium, for instance, the effect of which on the structure of the steel is in the opposite direction, resulting in a finer grain size, and investigation regarding the possibility of obtaining adequate ductility and toughness in steels of distinctly higher phosphorus content than those now employed which also contain small amounts of other elements would appear to be among the most promising of empirical investigations. It is not suggested that these ideas are in any way novel. Gillett, for instance, as far back as 1935, and many others, have already discussed the problem, and Andrew and Swarup have particularly indicated the beneficial effect resulting from the addition of 0·2 per cent aluminium to structural alloy steels of high phosphorus content, but they have been voices crying in the wilderness. As examples of the tensile properties which can be obtained from high phosphorus steels, a few typical results given by Jones are recorded in Table II :

TABLE II—*Mechanical Properties of Some High Phosphorus, Low Alloy Steels*

Composition, per cent				Normalising treatment	Yield point, tons per sq in	Maximum stress, tons per sq in	Elongation per cent on 2in	Reduction of area, per cent	Izod value, ft-lb
C	Mn	P	Alloy elements						
0·10	0·30	0·19	—	920 deg. C.	24	32	36	68	79
0·17	0·30	0·18	—	900 deg. C.	28·6	35·4	33	59	26
0·25	0·30	0·11	Cu 0·4	880 deg. C.	28	37	31	57	40
0·08	0·30	0·21	Cu 0·96	—	29	34·5	33	66	52

It must, however, again be emphasised that this discussion is restricted to ordinary structural steels statically loaded. Where fluctuating or shock stresses may be imposed, any marked increase in the phosphorus content, on the evidence at present available, would be highly dangerous, as would be the presence of high phosphorus in steels of higher carbon content.

I may perhaps be permitted also to discuss the effect of sulphur, though this is in the main economic. As is thoroughly well known, provided that the manganese content of the steel is sufficiently high, the sulphur exists almost entirely as a complex iron-manganese sulphide, out of solution. As a result of the forging operations, this sulphide is drawn out into threads, and then, as Brearley emphasised long ago, exerts an influence neither greater nor less than that of any other inclusions, such as silicates. It seems difficult to understand why the sulphur content should be so strictly controlled when other non-metallic inclusions are taken more or less for granted. So long as the stressing is longitudinal the effect of the sulphur is almost non-existent, though the transverse ductility and toughness may be considerably reduced. Brinell, many years ago, showed that even ½ per cent of sulphur in the presence of 1 per cent of manganese gave a material with adequate tensile properties, and which presented no special difficulty in production. More recently confirmation has been obtained, again on a steel containing 0·5 per cent of sulphur, the mechanical properties of which, taken from the centre of the ingot and after a forging reduction of 16·1 were as follows :—

	Yield point, tons per sq in	Maximum stress, tons per sq in	Elongation, per cent on 2in	Reduction of area, per cent	Izod value, ft-lb
Longitudinal ...	17	24	38	58	51
Transverse ...	12·4	13·2	3	11	18

The properties in the longitudinal direction seem entirely adequate, whilst the remarkably poor tensile properties in the transverse direction afford a most valuable warning, which is of general application, against overworking a steel when it is subsequently to be stressed transversely.

There is some evidence to suggest that the corrosion resistance of high sulphur steel is rather lower than that of normal material, but it certainly seems to be a case of straining at a gnat and swallowing a camel, to reject otherwise perfectly satisfactory steel because its sulphur content slightly exceeds an, in my opinion, unnecessarily low specification value.

Although the major portion of the carbon content of a soft steel exists in the pearlite as iron carbide, since ferrite at room temperatures has a negligible solubility for this element, this solubility may reach a figure of the order of perhaps 0·025 per cent just below the carbon change point. Further, it has been suggested by Benedicks, and even if his conclusions have not been confirmed they have not, so far as I am aware, been refuted, that the iron phase of the pearlite may contain carbon in solid solution in concentrations much greater than that which is present in the normal ferrite. When the pearlite becomes sorbitic and then troostitic, the corresponding increase in the electrical resistivity suggests more than strongly that the iron matrix is holding a still higher concentration of carbon in solution. This conclusion is in complete accord with the well-known physical-chemical fact that the solubility of a material increases as the particle size diminishes. It would appear at any rate not impossible that the increased strength of a steel in the sorbitic and then in the troostitic states is, as I think, due not so much to the increasing fineness of the state of dispersion of the carbide, as to the fact that this carbide is immersed in a matrix which itself is of a progressively higher carbon content. Not only does the solid solution of carbon in α-iron increase the hardness, but it may also lead to age-hardening phenomena which raise the strength still further, and quench-ageing low-carbon steels—that is, ageing after a quenching operation from a temperature below the A_1 point, despite the work which has already been done, eminently justifies further investigation.

Another element which causes age-hardening effects in steel is copper, and Table III shows the increased strength which can be obtained in an 0·3 per cent carbon steel (as cast) due to the presence of 1·2 per cent copper. In order to get such hardening the minimum content of copper or other alloying element must be above the limit of solid solubility, and in this case about 1 per cent is required to provide an appreciable hardening effect. By the simultaneous addition, however, of other metals in solid solution the solubility of the age-hardening element may be reduced, and corresponding effects, therefore, obtained at lower concentrations. Since at any rate in certain circumstances copper also reduces corrosion, it would appear that investigation from the age-hardening point of view of copper steels containing small amounts of several other elements might be a profitable field for investigation.

TABLE III—*Age-Hardening Effects of Copper on a Cast 0·3 per cent Carbon Steel*

Cu, per cent	Normalised at 900 deg. Cent. and precipitation hardened 3 hours at 500 deg. Cent.				
	Yield point, tons per sq in	Maximum stress, tons per sq in	Elongation per cent on 2in	Reduction of area, per cent	Brinell Hardness No.
0	26	42	14	22	175
1·2	39	53	10	15	230

Nitrogen, even in the amounts normally present in steels, is known to exert a considerable effect in enhancing strain-ageing. It may unfortunately, however, result in most serious embrittlement, and a field of fundamental research which calls for urgent examination is the full story behind the brittleness of materials which are normally ductile. The main difficulty in increasing the strength of engineering materials lies, indeed, in the fact that although this hardening can be effected without difficulty, it is in so many cases associated with a more or less marked embrittlement. A complete understanding of the reason for the brittleness should enable increased hardness and strength to be obtained without what is, at present, the insuperable drawback of inadequate ductility.

It has already been pointed out that surface decarburisation may exert serious effects on the mechanical properties, especially under conditions which may lead to fatigue. Mild carburisation of hot-worked or heat-treated material, by eliminating the weak ferritic surface, should produce material the mechanical strength of which was substantially higher. Such carburisation need not be very uniform, and it should be possible to effect it during production by incorporating a simple carbonising enclosure in the cooling, say, from the rolls.

It has been estimated that in Great Britain alone the total annual cost due to corrosion is now of the order of £200 million, and the detrimental effects on the steel itself have already been mentioned. The British Iron and Steel Research Association has recently published a most interesting little brochure outlining some of the practical conclusions reached by its Corrosion Committee. Rusting may be prevented, or at any rate retarded, by the addition of inhibiting reagents in the corrosive medium ; by modification of the design by reducing the danger of moisture lodging in the structure ; by changes in the composition of the steel and by efficient protective measures, including painting, the use of metallic coats or cathodic protection. Relatively inexpensive low alloy steels containing small percentages of chromium and copper may be three times as resistant as ordinary mild steel under atmospheric conditions, and it is justifiable to inquire whether sufficient use is made of such material in this country. Zinc is probably still the best all-round metallic coating for steel, though sprayed aluminium coats about 0·004in thick, under normal conditions of rusting, give almost as good results, whilst in contaminated industrial atmospheres lead coatings have proved useful. Cathodic protection, particularly of underground structures, is being increasingly adopted ; the process consisting in making the steel the cathodic element in an electrolytic cell, the protection being obtained at the expense of auxiliary electrodes, such as magnesium alloys.

Improvement by Heat-Treatment

Regarding improvements in the mechanical properties of steel by structural

changes due to heat-treatment, the subject is so vast that only two aspects can be dealt with here.

The importance of the crystal boundaries in determining the strength and ductility of a metal is generally appreciated, though it may be legitimate to point out that certain researches which suggest variations in the strength of the boundary may in reality be due to simultaneous changes which have been effected in the crystals themselves, to a result of the heat-treatment required as

TABLE IV—*Mechanical Properties of* 0·17 *Per Cent C,* 0·72 *Per Cent Mn Steel Bars* 1½*in Diameter*

Treatment	Yield point, tons per sq in	Maximum stress, tons per sq in	Elongation per cent on 2in	Reduction of area, per cent	Izod value, ft-lb
Water quenched 920 deg. Cent.	32	46	22	51	24
Water quenched 920 deg. Cent. and then water quenched 760 deg. Cent.	24	40	32	64	43
Oil quenched 920 deg. Cent.	23	36	31	65	92

produce modifications of the crystal size. We know, in fact, very little about the crystal boundary, and much recent theoretical work is based on assumptions which at the moment are pure speculation.

In this connection it may be pointed out that the idea of certain theorists that the crystalline structure extends more or less unchanged up to the very edge of the grain, and is almost immediately replaced by that of the new crystal, is pure assumption, unsupported by a vestige of evidence. It is equally true that Humfrey's hypothesis, that at the boundary there is a quite gradual swinging over from the orientation of one crystal to that of its neighbour, is similarly unsupported.

What, then, is the "thickness" of the boundary. An answer to this question cannot be given. In the same way we know nothing about the effects, if any, of heat-treatment on these boundaries and there is here a field of fundamental research of extreme importance.

Although, in general, the mechanical properties of an alloy improve as the grain size becomes smaller, there are exceptions. The small grain size steels obtained by controlled deoxidation with aluminium may give much higher Izod values than do coarser-grained materials, but, most curiously, not infrequently a lower yield stress. A 1½in bar of 0·35 per cent carbon steel with 1·4 per cent manganese and 0·2 per cent molybdenum, for instance, when oil quenched from 840 deg. Cent. and tempered at 550 deg. Cent. had a yield point of 65 tons per square inch in the coarse-grained condition against only 54 in the fine-grained state.

The improvement in the mechanical properties which can be effected by isothermal transformations is too well known to need emphasis, but the question does arise as to the possibility of devising simple forms of heat-treatment of a similar isothermal nature in ordinary engineering sections. Interrupted quenching is no new process, but the application of some such process to ordinary structural steels during their cooling from the hot rolls offers an interesting field of study.

Quite apart from the possibility of increasing the strength by producing a finer type of pearlite, rapid cooling results in the retention of some at any rate of the ferrite—the weakest constituent in the whole structure. Another aspect which should not be overlooked is that in steels of very low carbon content no quenching, however rapid, is sufficient to retain a fully martensitic structure, a not inconsiderable amount of ferrite always being precipitated. The martensite in such cases is itself, due to its low carbon content, relatively ductile, and being sandwiched in between the soft ferrite exerts a strengthening effect which is not associated with any serious embrittlement. Where such low-carbon steels are employed, would it be improper to suggest the deliberate quenching, even in water, of the sections as they cool down from the rolls—Table IV.

As an example of the type of simple isothermal transformation which I have in mind, the following may be taken as a general outline. If from the hot rolls the section be taken to the shears and then allowed to cool until a temperature of around 900 deg. Cent. is reached, they could then be "quenched" by dropping into a pit in which the temperature is allowed to fall fairly rapidly to, say, 400 deg. Cent. On attaining this temperature, and there is no need for it to be very accurately controlled, the lengths could be transferred to an isothermal furnace at a similar, or a slightly higher, temperature, kept there for a period which will depend on the composition of the steel, but even with a manganese content as high as 1·8 per cent need not exceed, say, fifteen minutes. The lengths could then be cooled in air and the steel possess a structure with less ferrite than that normally present, and a much finer, sorbitic, type of pearlite. There is nothing in such a scheme which need add substantially to the cost of the sections or interfere with the flow of the production.

I have already asked the engineer to decide whether he really needs so high a ductility as is often specified. Another question, quite as important, is whether he needs all the toughness, i.e. Izod value, that he tends to ask for, a question which Dr. W. H. Hatfield asked many years ago.

In the fully hardened, martensitic, state, the limit of proportionality of steel is very low; on tempering, this value rises up to about 400 deg. Cent., in the case of plain carbon steels, when the structure has become troostitic, and then falls again. It is this troostitic structure, then, which possesses the highest ratio of elastic limit to tensile strength. In most cases, however, a sorbitic structure, obtained at a higher tempering temperature, is preferred, presumably on account of its much higher impact value. A steel of the composition 0·26 per cent carbon, 0·30 per cent silicon and 0·75 per cent manganese in the form of bars 1½in diameter, water quenched from 900 deg. Cent. and tempered at 400 deg. Cent., gave the following mechanical results :—

Yield point	38 tons per square inch
Maximum stress	54 tons per square inch
Elongation per cent on 2in	15
Reduction of area	44 per cent
With an Izod value of	26ft-lb

Surely such a steel has both adequate ductility and toughness for many purposes despite its troostitic structure, and the high yield stress (for a 0·26 per cent carbon steel) should be undeniably attractive.

This lecture has consisted almost entirely of asking questions of the engineer, of the metallurgist and the theorist, and I am under no delusion in believing that I have been able to provide any answers to them. Of the engineer in particular the two outstanding points seem to me to revolve around the degree of ductility and toughness really required. If he could satisfy himself that at present he is asking for too much in both of these properties, the metallurgist would have no difficulty in providing him with material, still very far from brittle, and with greatly increased yield strength. To many of the questions which have been asked an answer can clearly only be given after research, both technological and scientific, which will require years to reach completion. The issues involved are, however, so big that there ought, in my opinion, to be no delay in beginning to think about them and in planning the work on which most important decisions will rest. The suggestions which have been made both for control of composition and of heat-treatment would inevitably lay extra burdens on the producers, and hence increase the cost of the material. It would be a matter, however, for the economist of the day to determine whether this increased cost was justified in view of the enhanced strength of the material, and therefore of the smaller sections which would be sufficient to perform the same service.

Maintenance of Telephone Systems

A PRODUCTIVITY team selected from the telephone staff of the General Post Office left this country at the end of last week for a tour in the U.S.A. This team, which is sponsored by the British Productivity Council, and which is under the leadership of Mr. R. W. Palmer, is to study problems of telephone plant maintenance. In announcing the team's departure, the British Productivity Council says that, since the war, the General Post Office and the American Bell system—which owns and operates four-fifths of the telephones in the U.S.A.—have kept in close touch by the mutual exchange of information and by occasional visits in both directions. The immediate object of the present team is to examine post-war telephone maintenance and staffing procedure in the U.S.A., and, in particular, to investigate new developments likely to have a direct bearing on the efficiency of the British telephone system. In the course of its tour, the team will visit the American Telegraph and Telephone Company in New York, and its various operating companies, the Bell laboratories at Murray Hill, and the Western Electric Company's manufacturing establishment at Chicago. Various independent telephone operating concerns will also be visited and contacts will be made with the appropriate American trade unions.

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Nos. 1949 : 1953 and 1948 : 1953. Price 3s. each. Each of these two specifications for copper alloy rods and sections specifies requirements for rods and sections of diameter not less than ⅛in and for forgings in the alloy, with regard to chemical composition and mechanical properties. Tables of tolerances on round, square and hexagon rods are included in the publication.

ELECTRODE BOILERS

No. 1894 : 1952. Price 12s. 6d. This new British Standard covers steel water-heating boilers, steel steam boilers and cast iron water-heating boilers. It applies to boilers to design temperatures not exceeding 650 deg. Fah., and is concerned solely with boilers for water-heating or for the generation of steam in which the water is heated by the passage of an alternating electric current through it. It deals with materials, construction and workmanship, scantlings, inspection and testing of electrode boilers of riveted, seamless, welded and cast iron construction. Safety valves are dealt with at length and electrical safety devices are also specified. In all cases the formulæ give the minimum scantlings and apply to boilers constructed throughout under competent supervision.

Changes in Spithead

By G. W. TRIPP, O.B.E., F.C.G.I., M.I.C.E.

THE fact that the paddle steamer "Merstone" has gone to be scrapped emphasises the end of a once recognised type on the service between Portsmouth and Ryde, and serves as a reminder of the gradual development in this class of ship, and it would appear to be a suitable time to give a brief review of what has taken place.

For many years these sailings were operated jointly by the then London and South Western, and London, Brighton and South Coast Railways, but after the grouping of the railways the London traffic has been concentrated on Waterloo. Until recent years the paddle steamer has reigned supreme, the vessels being of orthodox pattern, apart from three double-enders, such as the "Duchess of Connaught" (Fig. 1), which sailed on this route in the 'nineties. On the earlier ships the saloon accommodation was reserved exclusively for first-class passengers and as can be seen from the illustration of "Princess Margaret" the saloon was astern, while the foredeck was open and usually shared by third-class passengers, mails, trolleys of baggage, milk churns, &c. "Princess Margaret" (Fig. 2) was built in 1893, and had a length of 170·6ft; a breadth of 22·1ft; a depth of 8·5ft, and a tonnage of 260 gross. There was a general similarity between the steamers built between 1875 and 1893, and "Princess Margaret" was the last survivor, she being sold to Holland for scrapping after a successful career of thirty-five years.

A great improvement was apparent when the larger and more commodious "Duchess of Kent" was built in 1897, to be followed two years later by the still larger "Duchess of Fife" (Fig. 3), a paddle steamer of just under 400 tons gross, having a length of 215ft, a breadth of 26·1ft and a depth of 9·5ft. She was driven by compound diagonal engines with cylinders 26in and 55in diameter and a stroke of 54in. Both ships had fore saloons, which if somewhat bleak did at least afford shelter for third-class passengers. These vessels were largely used for excursion work, but the type was perpetuated by building similar though smaller vessels, to be used almost entirely

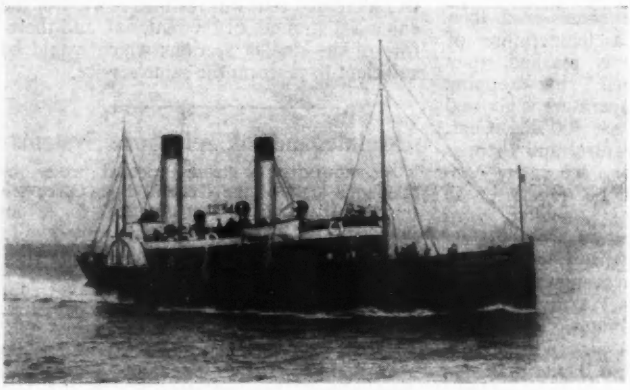


Fig. 1—"Duchess of Connaught"

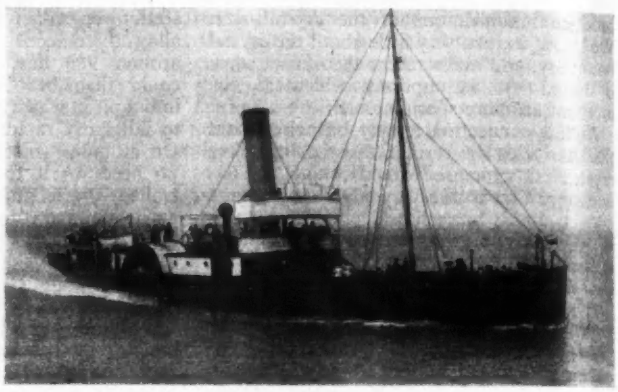


Fig. 2—"Princess Margaret"

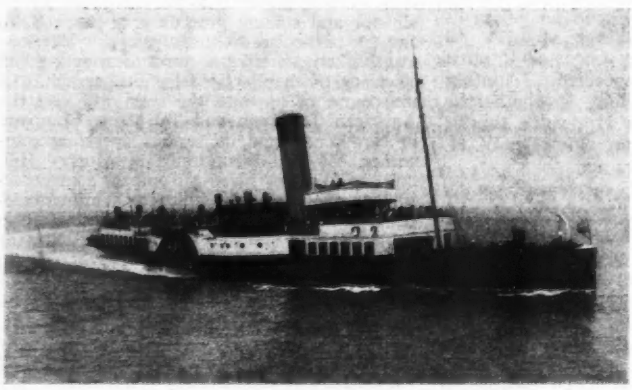


Fig. 3—"Duchess of Fife" (1899)

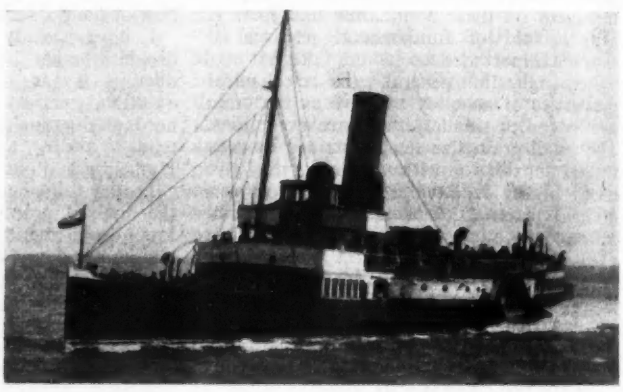


Fig. 4—"Merstone" (1928)

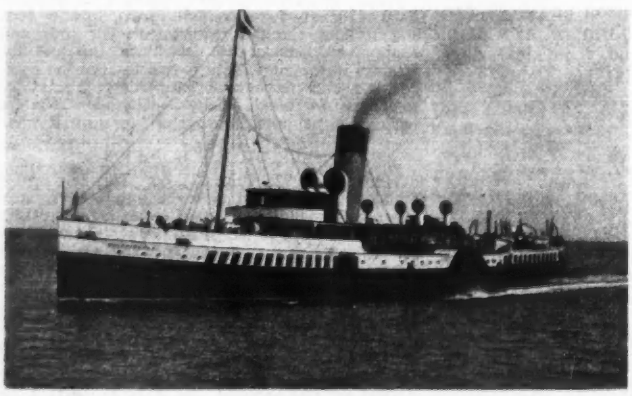


Fig. 5—"Whippingham" (1930)

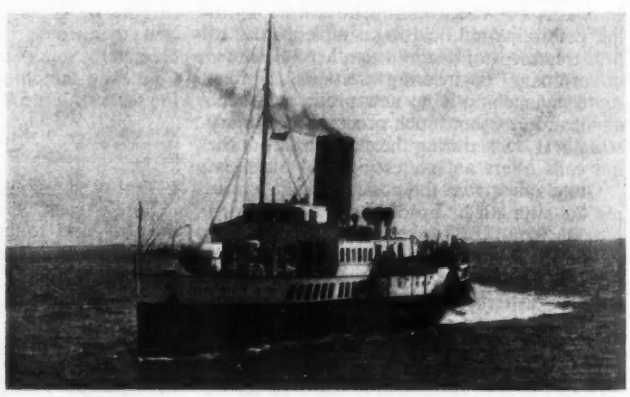


Fig. 6—"Sandown" (1934)

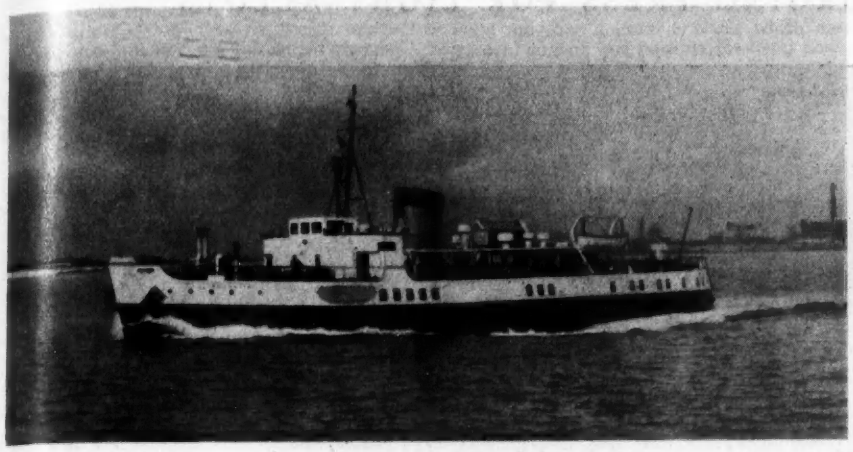


Fig. 7—Motor Vessel " Shanklin " (1951)

for the Island passage. In 1910 " Duchess of Richmond " appeared, but was destined to have a very short life, for she became a total loss in the Mediterranean in 1919, while her sister ship, " Duchess of Norfolk," built a year later, remained in service until 1936, when she joined the fleet of Cosens and Co. and became " Embassy." The two bigger ships survived the war, but " Duchess of Fife " was disposed of in 1929, and her sister was sold to the Medway in 1933, being renamed " Clacton Queen."

After the Great War the first steamer built to replace war losses was the 1924 " Shanklin," very similar to the " Duchess of Norfolk," and when in 1928 the two steamers " Merstone " (Fig. 4) and " Portsdown " were put on service, as they were generally similar to their predecessors, it appeared as if the standard vessel for this passage had been determined. The principal dimensions of these boats were : length, 190ft ; breadth, 25·1ft ; depth, 8·7ft ; tonnage, 342 gross. They were driven by compound diagonal engines with two cylinders of diameters 27in and 51in, with a stroke of 54in.

In 1930 a revolutionary step was taken when two sister ships, " Southsea " and " Whippingham " (Fig. 5), replacements of the two larger " Duchesses," came to Portsmouth, they being much the largest steamers built for the Island service. They had their promenade deck extended to the bows and their saloon accommodation was superior to anything that had gone before. Though largely employed on cruises and excursion work, they proved very valuable at the week-end to help to cater for the ever-increasing traffic between the mainland and the Island. They were built by the Fairfield Shipbuilding and Engineering Company and their principal dimensions were : length, 244ft ; breadth, 30·1ft ; depth, 10·5ft ; tonnage, 825 gross. Powerful two-cylinder compound engines, with cylinders 30·5in and 59in diameter and a stroke of 54in, gave the ships a speed of 16 knots. They had accommodation for 1350 passengers. Unfortunately, " Southsea " was a war casualty, being sunk off South Shields in 1941. So satisfied was the Southern Railway with these ships that their design was used as the basis for a new steamer of rather smaller dimensions, intended to be used almost exclusively for the Portsmouth-Ryde sailings. As a result, in 1934, " Sandown " (Fig. 6) came from the yard of William Denny and Bros., Dumbarton, and soon found favour with the travelling public. She can carry 947 passengers, has a length of 216ft, breadth of 29·5ft, depth of 10ft, and a tonnage of 684 gross. A number of innovations were incorporated in her and she was the first on this route to be driven by triple expansion engines, with cylinders having diameters, respectively, of 16in, 25·5in and 41in, with a stroke of 63in, which gave her a service speed of 14·5 knots. She also has a large observation lounge for third-class passengers, first-class accommodation superior to anything formerly provided, and a spacious restaurant on the lower deck. Another innovation was the cruiser stern. So successful did she prove that three years later a sister ship, " Ryde," came from the same yard. Though of slightly lower tonnage, 603 gross, " Ryde " can take 1011 passengers.

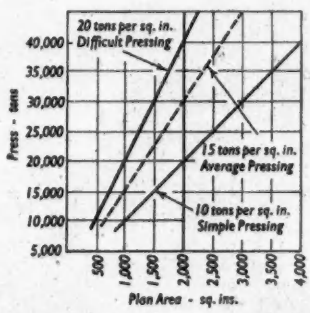
Again it would have appeared that finality had been reached and as both of these steamers happily survived the war, it was expected that similar vessels would be ordered to replace other war losses, and it came as a great surprise when it was announced that two twin-screw ships driven by diesel engines were being ordered. The chief characteristic of " Southsea " and " Brading " is their great breadth in relation to their length, for although only 200ft long, their breadth is 46ft. Both are Denny products and were completed in 1948. They were fully described in THE ENGINEER* so that further details need not be given here. They were followed in 1951 by a third and very similar vessel, " Shanklin " (Fig. 7), the chief difference being that her lifeboats are raised and so do not obscure the promenade deck. She was also the first one-class ship, the Southern Region thereby following the lead of their friendly rivals at Southampton.

It would be rash to affirm that finality has at last been reached.

12,000 - Ton Forging Press

As part of the policy of High Duty Alloys, Ltd., to provide large forgings in light alloys the company has installed at its Redditch Works a 12,000*-ton forging press. This press, which weighs* 800 *tons, is arranged to give pressures of* 4000, 8000 *and* 12,000 *tons to produce precision forgings of a size not available previously, so that designers can use large forged components in preference to parts assembled by fabrication.*

THE increasing size of aircraft has created a need for larger components and this has been temporarily satisfied by the 12,000-ton forging press which has been installed at the Redditch Works of High Duty Alloys, Ltd., The press was formally put into service on Tuesday of last week, February 24th, by Sir Frank Spriggs, the chairman of the company, and managing director of the Hawker Siddeley Group, Ltd. It is expected that the new press, which is a precision tool, by producing light alloy components to close tolerances, will result in an overall saving in time and materials as compared with the drop hammer. Machining time will be greatly reduced, but although against any savings in this direction there must be set the extra cost of the necessary dies, there will be an additional saving of materials by reason of the lighter weight of a forging compared with a fabricated component.



Press Capacity and Plan Area Relationship

Before inaugurating the press a paper with the title " The Potentialities of Large Forging Presses " was introduced by Mr. H. G. Herrington, the managing director of High Duty Alloys, Ltd., and read by Mr. G. W. Richards, the manager of the forging division. In the paper, which we briefly summarise, 40,000-ton presses were mentioned, and the statement was made that there is a forging size in high-strength aluminium alloys which it is impracticable to exceed. A difficulty in making light alloy die forgings is the need for the work to be done hot and it was stated that with the alloy at 400 deg. Cent., when the plasticity is four times that when cold, the pressure required for a hot die pressing varies from 10 to 20 tons per square inch. The figures quoted indicated that larger presses could not make cold pressings and a relationship between plan area of a component and the power required was shown by a graph which we reproduce herewith. Another graph which we illustrate showed the minimum pressures required to upset a slab of 2000 square inches plan area over a range of thicknesses at 400 deg. Cent. and indicated the sharp rise in pressure for thicknesses below 2in.

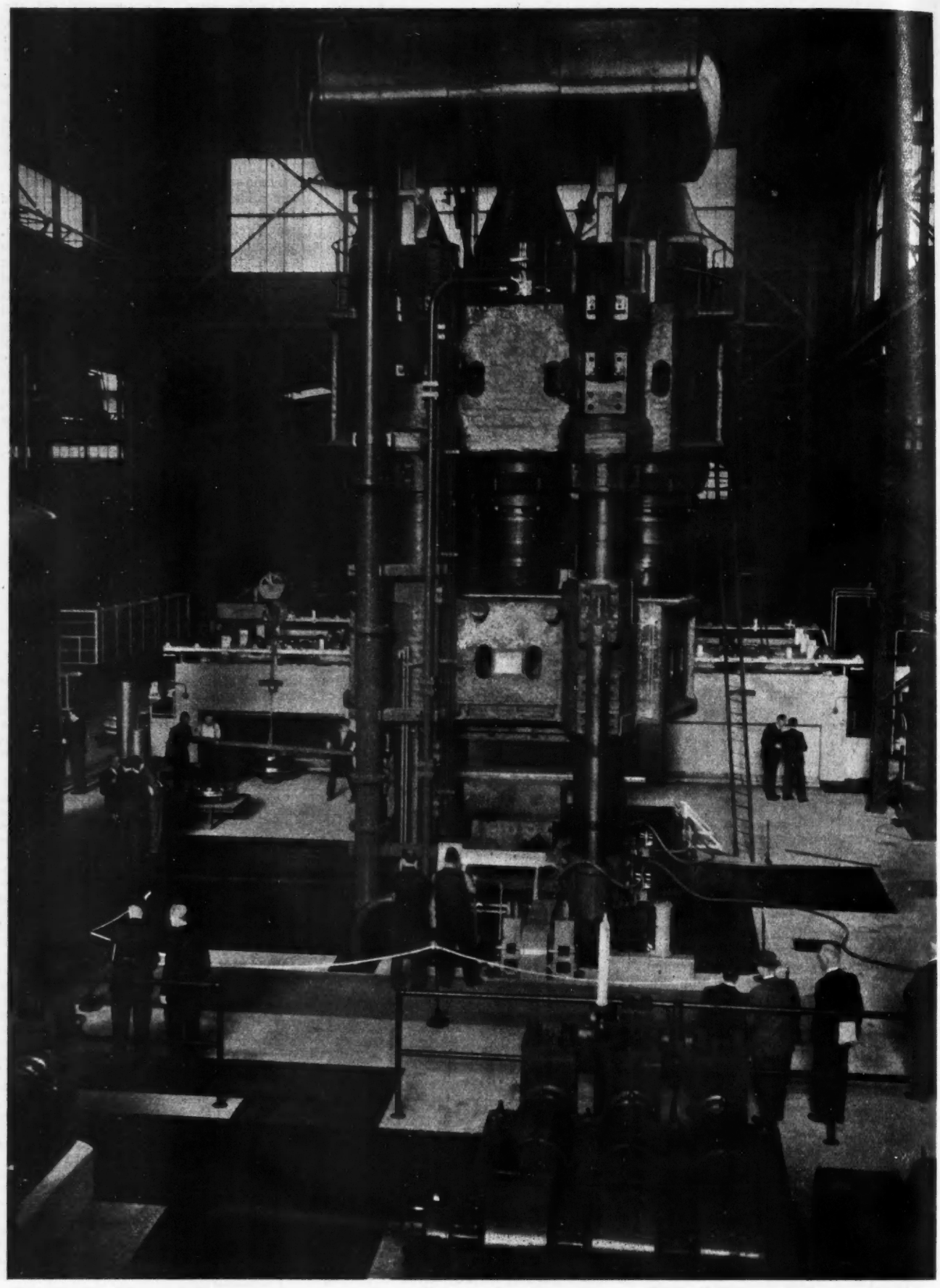
The selection of 20 tons per square inch as the upper limit of die pressure, when die steels have a yield strength of between 45 and 50 tons per square inch at 400 deg. Cent., was explained by stating that loading on the die face was uneven so that higher average pressures may cause die deflection and loss of accuracy. The five factors affecting dimensional tolerances were discussed and stated to be : thermal expansion and contraction of the press dies and press component ; elastic deflection or plastic deformation of the press dies ; elastic deflection of the press ; distortion during removal from dies ; distortion of component during final heat treatment.

The preparation of forging stock was touched upon, and in a note upon die blocks it was mentioned that those used on a press where there is no shock impact need weigh no more than two-thirds of those used on a hammer. Various designs of components were discussed and an exhibition of models of certain proposed items included a statement of the power required for production.

A historical survey reviewed the developments in Germany where the successful operation of

* THE ENGINEER, Nov. 26, 1948, page 541.

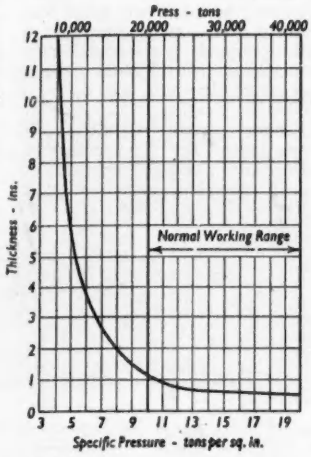
12,000-TON FORGING PRESS FOR LIGHT ALLOYS



15,000-ton presses had encouraged the preparation of designs for presses up to 50,000 tons. In America, a 16,000-ton press has been in operation for some time and the current programme was stated to include two presses of 44,500 tons, four of 31,250 tons, and two of about 22,250 tons; however, it was recalled that the potentialities of such big presses are unknown.

Description of the Press

To accommodate the 12000-ton press a considerable amount of structural work, both below and above ground level, has been necessary. The press, which has an overall weight of 800 tons and has taken



Upsetting Pressure and Thickness Relationship

ten months to build, attains a height of 42ft 9in above the ground and projects 13ft 7in into a large underground chamber which houses the hydraulic system for moving the die table. About 2500 tons of earth was removed to form this chamber, which is of ample size to allow maintenance work to be carried out, and, to assist in this, the floor area in the vicinity of the press is covered by chequer plating which is easily removable. For the foundations of the press itself, approximately 500 tons of concrete was poured, while a considerable area of the shop floor had to be concreted to take the various ancillary equipment required. The principal above-ground work involved the raising of a 220ft length of roof from 40ft to 87ft and the installation of a 100-ton crane, having an auxiliary hoist of 25-ton capacity, which called for the erection of heavier stanchions to support the crane track. Other work necessary to the scheme was the provision of a new electricity substation.

Our illustration of the press, which has a stroke of 10ft, 12ft daylight and a die table measuring 6ft by 13ft, and was built by Davy and United Engineering Co., Ltd., to designs by the Loewy Engineering Company, Ltd., includes one of the hydraulic pumps in the foreground, and the gas-fired preheating furnaces in the background.

Special anchor bolts positioned in the concrete foundation hold down the two bedplates of the press, each of which weighs 14 tons. Superimposed are four adjustable plates which are recessed to contain and position the lower ends of the four supporting columns. They each have a diameter of 31in, are 44ft 9in in length, weigh 53 tons and pass through both the lower platen and the moving crosshead to end above the top platen. The columns serve a dual purpose. They act as a tie for the press, and at the same time they carry and guide the moving crosshead.

Three castings, which are dowelled, dovetailed and bolted together, make up the lower platen and consist of two side sections of 42 tons each and a centre section weighing 64 tons. The latter casting forms the bed to carry the hydraulically controlled moving table to which is fixed the bolster and bottom forging or pressing die. The top bolster and forging or pressing die are located and attached to the lower face of the moving crosshead, which weighs together with its bushes 108 tons, by spigot recesses and tee slots. Three hydraulic rams actuate the crosshead and each weighs 28·5 tons and measures 4ft 3in in diameter by 15ft in length. The rams operate in cylinders, weighing 36 tons each, attached to the upper platen, which is practically identical in size and shape with the moving crosshead and weighs 94 tons. On the top of upper platen the buffer vessel or shock absorber is mounted and into it the water under pressure is released before entering the prefilling vessels.

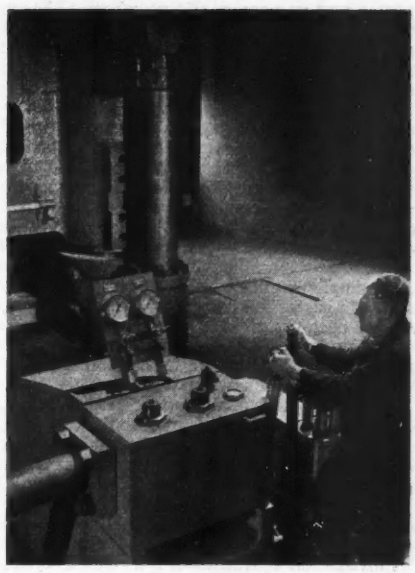
Auxiliaries

Our line drawing shows a diagrammatic arrangement of the air and hydraulic system, and the necessary ancillary equipment forming part of the installation consists of a battery of four treble-ram pumps each driven through reduction gearing by a 550 h.p. Metropolitan-Vickers electric motor. There are two prefilling vessels which are connected to the buffer vessel and which contain low-pressure water at 40 lb per square inch. The water supply for prefilling vessels and pumps is drawn from a storage tank of 6500 gallons capacity. High-pressure water passes from the pumps to two water bottles which are interconnected to a battery of twelve air vessels containing air, at a pressure of 300 atmospheres, supplied by two Belliss and Morcom compressors, each driven by a 16 h.p. electric motor.

At the other end of the shop are three gas-fired furnaces, supplied by the Templewood Engineering Company, Ltd., which are approximately 30ft long by 11ft wide. Each furnace is of 10 tons capacity and is fitted with twin electrically operated conveyors having channel section slats. Indirect firing has been adopted and none of the products of combustion enter the muffle. There are five zones in each furnace and their individual temperatures are closely controlled and checked by temperature recording instruments, which are mounted in a special room. The billets are preheated to the required temperature suitable for the particular alloy and then pass through twin hand-operated doors and are ready for lifting by crane on to the moving table. The upper and lower dies are maintained at their correct temperature by heaters burning town's gas at boosted pressure and the hydraulic rams are automatically lubricated on a time basis at a maximum pressure of about 200 lb per square inch.

In the immediate vicinity of the press bay is the electricity substation equipped by Crompton Parkinson, Ltd., which has a 11,000V supply taken from the main substation. The supply is connected through a high-tension switchboard to two 1500kVA transformers, supplied by the British Electric Transformer Company, Ltd. The secondary voltage is 440V, which supplies the pump motors, &c., through the low-tension switchboard.

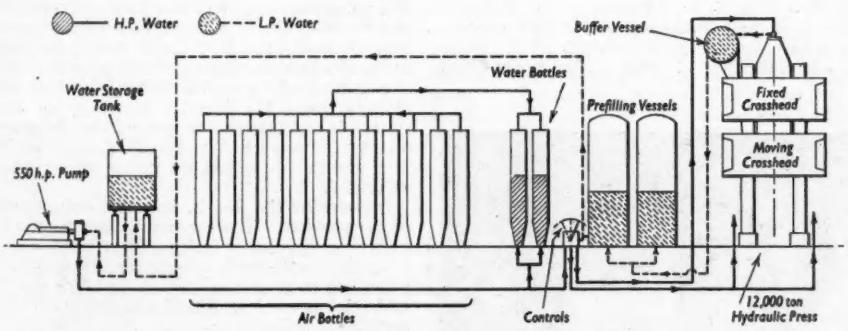
Our photograph shows the central main control panel, to which low-pressure and high-pressure



Press Control Panel

water circuits are connected, which is located close to the press and regulates the main movements of the installation. A selector determines whether power will be given by one, two or three of the crosshead rams to exert a pressure of 4000, 8000 or 12,000 tons respectively. A single lever regulates the movement of the crosshead, from the stop or neutral position a forward movement to the next notch takes up the idle stroke and using prefilling pressure, approximately 40 lb per square inch, plus the deadweight of crosshead and rams, lowers the crosshead. At the point of impact of the upper die with the billet the lever is pushed further forward to cause the press to exert the amount of power selected, after which the lever is returned to the neutral position when the load remains static. On pulling the control lever back from neutral the pressure is released from the rams into the buffer vessel and so back to the prefilling tanks, and the crosshead is raised by two return cylinders operating under full pressure. Another control operates the moving table and a third is connected with the ejector mechanism. Both these controls are interlocked so that the table cannot be moved while the ejector is in the up position.

Various electrical circuits automatically control the hydraulic system by operating by-pass valves and starting or stopping the pressure pumps. The safety system incorporates controls such that if the water should drop below a minimum level a low-level stop valve is shut and no more water can be taken from the bottles until the normal working level has been restored. The low-level water conditions are indicated aurally by a warning given by a siren. Should the pressure in the bottles rise above the normal 300 atmospheres by reason of the water level being too high a continuous note is sounded on a hooter until such time that conditions are returned to normal. In addition, there is an indicator panel, at the control position, which not only shows by means of coloured lights the pumps on load, but also gives information regarding the position of the low-level valve.



Hydraulic Circuit Diagram

Peat-Fired Open-Cycle Gas Turbine

In this article is described the peat combustion plant used in conjunction with an open cycle gas turbine. Its development has been undertaken by Ruston and Hornsby Ltd., for the Ministry of Fuel and Power. The turbine is basically similar to the company's 750kW set, now under batch production. Considerable interest attaches to the "fluidising" method of handling the dry fuel under the full cycle pressure. This technique, together with methods of dewatering and drying the peat, its analysis and combustion, and some ash erosion characteristics, are given.

THE advent of the industrial gas turbine has in recent years nurtured the prospects of utilising peat as a source of fuel, where hitherto the nature of the deposits have rendered its use uneconomic in more conventional plant. In such a project two inherent characteristics of the gas turbine can be exploited.

As the transport of peat is not thought to bear economic consideration, and as very large deposits tend to be an exception in Great Britain, a conventional power plant of reasonable size could spend only part of its life on any given deposit. In this connection the gas turbine, with its low specific weight and the kinematic construction to which it lends itself, represents a particularly portable unit and one needing only simple foundations. Apart from this aspect, the gas turbine particularly when operating with an open-cycle exhausts a characteristically high quantity of high-temperature gases which can be employed and is an ideal medium to reduce considerably the water content of the peat.

The development of this project is proceeding on two lines in this country under the direction of the Ministry of Fuel and Power, and progress was reported in THE ENGINEER of January 18, 1952.

At that time we were able to describe the peat burning plant undergoing trials at John Brown and Co. Ltd., Clydebank. It will be recalled that this installation operated with a closed cycle, the peat being burned in an air heater at atmospheric pressure. The other approach mentioned was that being undertaken by Ruston and Hornsby, Ltd., which was then developing a combustion system to work in conjunction with the more simple open-cycle gas turbine and based on the company's 750kW set.

It was to see this installation, which is now running, that we visited the Lincoln works of Ruston and Hornsby, Ltd., last week. Our illustration Fig. 1 shows the gas turbine with its combustion chamber and a diagrammatic arrangement of the complete installation is given in Fig. 2. The gas turbine is basically the same as the Mark TA version which the company has now under batch production and to which we shall refer in a subsequent article.

Several main items of research were involved in the handling and combustion of peat, these being conducted independently of the prime mover. Amongst them were methods of dewatering and drying the peat; feeding the peat into a combustion chamber against the cycle pressure and the associated problem of controlling the plant; burning the peat in a combustion chamber operating under pressure; ash erosion and deposit on the turbine blades and its prevention.

In examining these problems the Ministry and Ruston and Hornsby Ltd., collaborated with many organisations interested in peat, both in Britain and abroad, notably the Peat Division of the Department of Agriculture for Scotland, the Bord na Mona in Eire, Staatliche Torfwerke (Seshaupt and Schussenried) in Germany, and the authorities in Denmark and Sweden.

Dewatering and Drying the Peat.—The researches on the dewatering of peat have been and are being carried out by the Ministry of Fuel and Power in collaboration with the Peat Division of the Department of Agriculture for Scotland. They have been developing the Madruck process, by which a considerable amount of the water can be pressed out of the peat after a proportion of dry dust has been mixed with the raw peat to provide leakage channels through which the water can escape. By this process it is possible to remove 5 lb of the original 9 lb of water associated with each pound of peat solids. There is sufficient heat in the turbine exhaust to dry off the remaining 4 lb of water. This process appears to have considerable advantage in this country, where the seasonal labour necessary for most methods of producing peat fuel may be difficult to obtain. The rotary louvre turbine exhaust dryer manufactured by Dunford and Elliott (Sheffield), Ltd., is being supplied for this duty.

In certain locations, however, it may be advantageous to use an air drying process for winning the peat, in which case the thermal drying required would be very much less. If the milled peat process, one of the most successful means of air drying, was used, which produces peat having about 1 lb of water associated with every pound of dry peat, the drying problem would indeed be simple.

Peat Feeding System.—A problem which may not be apparent at first sight is that of feeding pulverised peat to a combustion chamber against compression pressure. Pressurising the fuel appears possible in a number of ways, but the only methods taken to a practical stage so far are the lock hopper system and the pulverised fuel pump. Of these, the latter is the most attractive because of its greater simplicity in operation, and running experience has now been gained on a rotary pump designed and manufactured by the Incandescent Heat Co., Ltd. The pump comprises a carrier plate containing a number of pockets which receive fuel at atmospheric pressure at one station and carry it round to another station, where entraining pressure air is admitted, which carries the fuel out into the delivery line. The inherent simplicity of this system is complicated in practice by the seals necessary to restrict air and fuel leakage to a low rate, and in this respect the pump appears very successful.

Pressurising the fuel is, however, only a part of the problem. The apparently simple process of getting pulverised fuel out of a hopper and metering it sufficiently closely for a gas turbine proved to be a serious obstacle, and in order to solve this problem a knowledge of the flow of particles of solids was necessary.

The flow of solids in a hopper is found to be localised to a vertical zone above the outlet, and this downward moving column should be replenished by an inward flow at the upper surface. Stoppage of flow can result from failure of the inward flow, giving a result termed "coring." Sometimes inward flow takes place at a level lower than the upper surface, leaving peat above in the form of a dome (Fig. 3). The angle of repose of pulverised fuels varies considerably with settling period, and this, combined with the hygroscopic and fibrous nature of peat, makes it a difficult material to handle until the correct techniques are used.

Such methods as inserting steel sheets in the hopper, enamelling the walls, the use of stirrers, air jets, vibrators and the application of low-pressure air to the peat surface, met with no

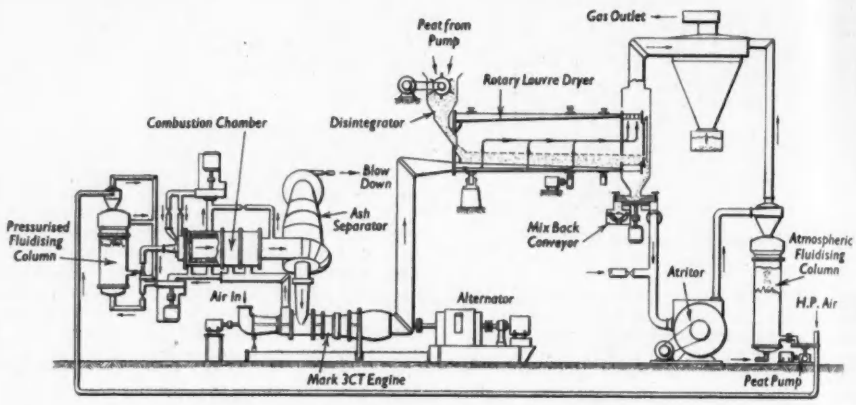


Fig. 2—Diagrammatic Arrangement of Installation

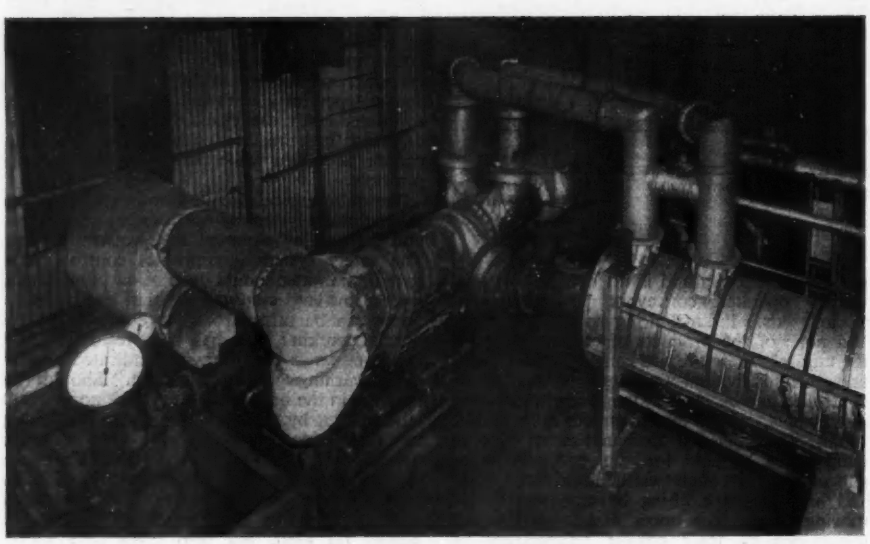


Fig. 1—Gas Turbine and Combustion Chamber

success. More successful methods were to rock the hopper at some optimum frequency and amplitude, or to use a rectangular hopper with an elongated discharge aperture.

A further disadvantage of a typical hopper is that the outflow rate per unit area is low, an average figure for pulverised peat being 0·15 lb per square inch per second, which necessitates a large discharge aperture and limits the choice of feeder ; also it has been found that the quantity discharged is independent of the head of solids in the hopper. Screw feeders were found to be unsatisfactory for the feeding and metering of fuel and were prone both to failure by jamming and to the introduction of undesirable pulsations in the feed.

A completely satisfactory solution to the

Fig. 3—Flow Failure in a Conical Hopper

problem of feeding and metering was eventually found by keeping the peat in a " fluidised " state by percolating air through it.

The term "fluidisation" implies that particles of solids are maintained in suspension in a moving air stream. A drag force is thus produced on them equal and opposite to their weight, and the required air velocity will be equal to their free falling speed. For pulverised peat particles the balance between weight and drag occurs at low Reynolds numbers, which are confined approximately to the range covered by Stokes Law. In a fluidised peat bed, however, there is a wide range of particle sizes giving rise to interparticle interference and friction between the solids and the wall of the column. In spite of these factors, conditions of fluidisation can be attained, and, provided the range of particle size is not too wide, there then exists a minimum air velocity which will produce fluidisation, the properties of the resulting solids-gas mixture being similar in many respects to those of a liquid. The critical fluidising velocity of the pulverised peat used in the turbine is 4 centimetres per second. The fineness of the peat is such that 55 per cent will

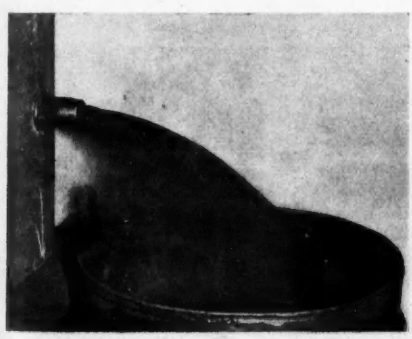


Fig. 4—Flow of " Fluidised " Peat

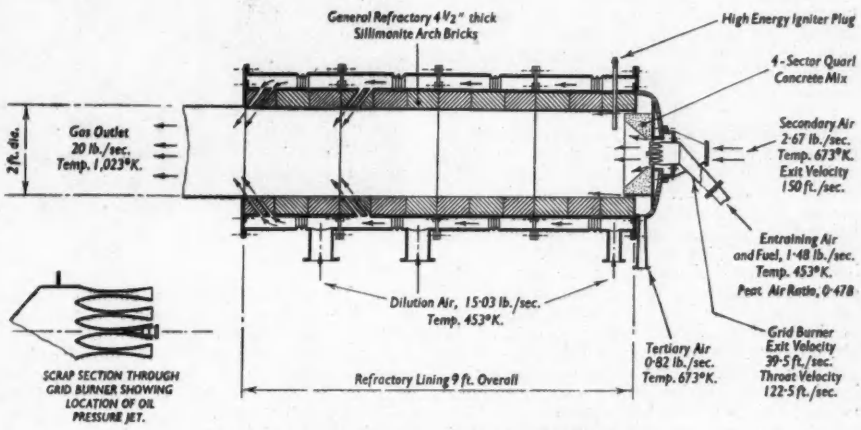
pass through a 200-mesh British Standard screen and 7 per cent is caught on a 60-mesh screen.

The success of the fluidisation technique depends, to a large extent, on the fine division and uniform distribution of the fluidising air. After much experiment a satisfactory method was developed using an underbed of No. 16 steel shot, although for small-scale work sintered stainless steel and porous ceramic discs were used. A study was made of the effect of solids static head, and fluidising air density and viscosity, on the critical fluidising velocity. In the range of pressures from one to three atmospheres, and at temperatures from ambient to 200 deg. Cent., the critical fluidising velocity was found to be independent of the three variables. Theoretically, this velocity is inversely proportional to the absolute viscosity, but since the air temperature rapidly drops to that of the peat, viscosity effects are almost eliminated. The flow of fluidised peat from a column such as shown in Fig. 4 was found to be almost directly proportional to the solids static head and to the area of the outlet orifice.

A pressurised fluidising column having an effective capacity of 1000 lb of peat was tested in conjunction with the peat-fired turbine. Engine control was maintained manually by metering the fluidised peat, using a ¾in full-way gate valve, and results indicate that the fluidised feeder meets the special requirements of the open cycle gas turbine.

Combustion of Peat

The choice and design of a combustion chamber to burn peat is largely dependent on the moisture content of the peat at entry to the chamber, and on the fineness to which the peat has been ground. Little information is yet available upon the combined effect of moisture content and fineness on the combustion of peat and present practice is to accept the fineness provided by a commercial grinder which gives an acceptable quality of combustion with up to 35 per cent moisture content. Whilst drying and grinding are vital characteristics of peat, its chemical properties are also of importance. From the proximate and ultimate analyses given in Table I it will be seen that peat has a high volatile and low fixed carbon content leading to a rapid temperature rise in the primary combustion zone. Peat also contains, for a solid fuel, a relatively low ash content, which, combined with the other factors, led to the choice of a refractory lined non-slagging type of chamber. The basic design for this combustion chamber, together with a grid-type burner, was based on information supplied by the Fuel Research Station, which has developed a combustion system along these lines to burn coal at atmospheric pressure (Fig. 5), and on which some preliminary peat combustion tests were carried out in the early days of the development.


General Refractory 4½" thick Sillimanite Arch Bricks
High Energy Igniter Plug
4-Sector Quarl Concrete Mix
2ft. dia.
Gas Outlet 20 lb./sec. Temp. 1,023°K.
Secondary Air 2·67 lb./sec. Temp. 673°K. Exit Velocity 150 ft./sec.
Entraining Air and Fuel, 1·48 lb./sec. Temp. 453°K. Peat Air Ratio, 0·478
Dilution Air, 15·03 lb./sec. Temp. 453°K.
Tertiary Air 0·82 lb./sec. Temp. 673°K.
Grid Burner Exit Velocity 39·5 ft./sec. Throat Velocity 122·5 ft./sec.
Refractory Lining 9 ft. Overall
SCRAP SECTION THROUGH GRID BURNER SHOWING LOCATION OF OIL PRESSURE JET.

Full load conditions are given °K = Kelvin Scale—(°F = °K × 9/5 − 460) (°C = °K − 273

Fig. 5—Peat Combustion Chamber

Table I—*Typical Peat Chemical Analyses*

	Per cent
Proximate analysis (dry basis) :	
Volatile matter	67·85
Fixed carbon	30
Ash	2·15
Ultimate analysis :	
Carbon	55·60
Hydrogen	5·50
Nitrogen	1·20
Sulphur	0·25
Ash	2·15
O_2 (by difference)	35·3

It is desirable with solid fuels to radiate heat rather than convect it into the ignition zone, and for this reason a refractory quarl is used. For starting purposes the refractories are heated up by means of a pilot oil burner, following which peat, together with " entraining " or " primary air," is admitted to the chamber and ignition can be completed within an inch or two of the grid burner nozzles. Once ignition of the peat has been established, which would be at a refractory temperature of about 800 deg. Cent., the pilot oil burner is shut off. It is eventually hoped to correlate the ignition characteristics in a combustion chamber with inflammability as measured by Godbert's apparatus for varying degrees of fineness and moisture.

Following ignition, the combustion of volatiles takes place immediately and further air (" secondary ") is required. This air enters between the fuel nozzles of the burner and the rate of mixing is controlled by adjusting the relative velocities of the primary and secondary air supplies. The secondary air is preheated to about 400 deg. Cent. to avoid chilling the combustion process. In order to avoid elevated refractory temperatures a tertiary air feed is provided close to the wall and, in addition, forms a further source of combustion air. Refractory temperatures of 1000 deg. Cent. are normal practice using " Sillmanite " bricks containing about 63 per cent alumina. The optimum quantity of primary, secondary and tertiary combustion air has been found by rig testing to be about 120 per cent of that theoretically necessary for complete combustion, but this depends on the volatile content of the fuel. Calculations show that for 30 per cent wet peat the temperature rise due to burning the volatiles is then about 800 deg. Cent., and it has also been found that the velocities through the burner can be higher for finer and drier peat due to its ease of ignition and higher rate of burning.

Combustion of the fixed carbon is a slow process, in which large-scale turbulence plays very little part. To gain any assistance at all from such turbulence the cost in pressure loss would be high. The controlling factors in the combustion of fixed carbon are therefore particle size, residence time and temperature. The advantage of a refractory-lined chamber in maintaining a high temperature throughout its entire length is therefore evident. It can be shown that a 75 micron particle of peat (200 mesh) requires a residence time of about 90 millisecs to burn, which, using an average gas velocity of 50ft per second, represents a distance of 4½ft. This figure is in general agreement with experimental results. A compromise is, however, required here and with present commercial grinding techniques, fuel which passes approximately 55 per cent through a 200-mesh screen is used. A combustion efficiency of 95 per cent can then be attained and the loss is due almost entirely to the few largest particles, which would require an extremely long residence time to burn completely. Dilution down to turbine inlet temperature is carried out at the downstream end of the combustion chamber through 1in diameter ports.

The combustion intensity of the chamber as a whole is low compared with an industrial gas turbine oil-fired chamber, being about $1·3 \times 10^5$ C.H.U.s per cubic foot per hour per atmosphere, but high compared with boiler practice. The

volatiles which account for half of the heat release burn in the primary zone with an intensity of about $6{\cdot}0\times10^{6}$ C.H.U.s per cubic foot per hour per atmosphere. Since the residence time and temperature are high, the loss of combustion efficiency in gaseous products is negligible in this type of chamber. Provided the ash content of the fuel is known, sampling of the exhaust solids gives the complete picture. With typical peat about 60 per cent combustible, matter in the exhaust indicates a loss of combustion efficiency of 10 per cent.

Atmospheric rig tests have shown the grid burner to be particularly flexible in operation and with fairly dry peat up to 240 per cent of the stoichiometric quantity of air has been introduced for combustion. This should permit part-load running on the engine down to about 20 per cent, using peat only. Engine tests are now taking place and the performance to date is satisfactory.

Ash Erosion and Deposition.—Compared with most solid fuels, peat does not contain much ash (about 2 per cent). The gas turbine assembled in its present form contains only a rudimentary form of ash separator—a screen with $\frac{1}{16}$in gaps. The plant has been assembled in this form with the expectation of some blade erosion and deposits. This step has been taken in order to obtain quickly an idea of the magnitude and nature of the erosion problem to be solved, as it is anticipated that a very long period of running will be required before an appreciable amount of erosion occurs, when an effective ash separator is fitted.

Once the wear on the turbine blades has become appreciable, a cyclone separator, as shown incorporated in the diagram, Fig. 1, will be inserted between the combustion chamber and the high-pressure turbine.

Present Position

In the arrangement of the plant as it is at present air enters through the Vokes air filters and passes through the axial compressor to the combustion chamber. The air from the compressor is divided into several streams, one of which flows as fluidising air to the bottom of the high-pressure "fluidised" column. Another is the primary air line carrying the peat into the combustion chamber. Other streams supply the secondary and tertiary air to the upstream end of the combustion chamber. The bulk of the air, however, is dilution air, which enters at the downstream end of the combustion chamber. The hot gases pass through the screen mentioned in the previous section and enter first the high-pressure turbine, then the low-pressure turbine and finally pass to the exhaust. Peat enters the system at the peat feeder, whence it is fed to the Atritor grinder. After grinding, a cyclone separates the peat dust from the carrying air stream and discharges it into the low-pressure "fluidised" column. From this column it flows into the peat pump which transfers it into the high pressure air stream carrying it into the high pressure "fluidised" column. The high-pressure stream of air from the peat pump is provided from the works mains.

The engine is controlled manually from the $\frac{3}{4}$in fullway gate valve at the bottom of the peat pump fluidising column.

Future Developments.—When the turbine plant has been developed in Lincoln to a satisfactory degree it will be taken to a peat bog in Scotland, there to join the Dunford and Elliott dryer and the dewatering press at present being manufactured by John Shaw and Sons (Salford), Ltd. The complete plant will then be run for a long period in order to determine the best method of operating such a power plant and to determine precisely the economics of such an installation.

In the event of an open-cycle gas turbine being run in conjunction with the milled peat process there are two possibilities: one is to use the exhaust gas heat in order to dry more peat than is required by the gas turbine itself, this dry peat being then briquetted and sold as a domestic fuel; alternatively, a more complex gas turbine cycle could be used involving intercooled compression in order to raise the thermal efficiency. The possibilities are now being investigated of using similar plants for generating power from waste wood, brown coal, and other combustible vegetable products.

Installation of Long Conductor Rails on the Southern Region

Considerable savings in time, labour and material have been made possible by the introduction of new methods and equipment for the renewal of conductor rails on the Southern Region of British Railways. With the new equipment a gang of six men can unload 1¾ miles of conductor rail in 4½ hours, and sixteen men can lay-in and bond ½ mile of the rail in a similar time.

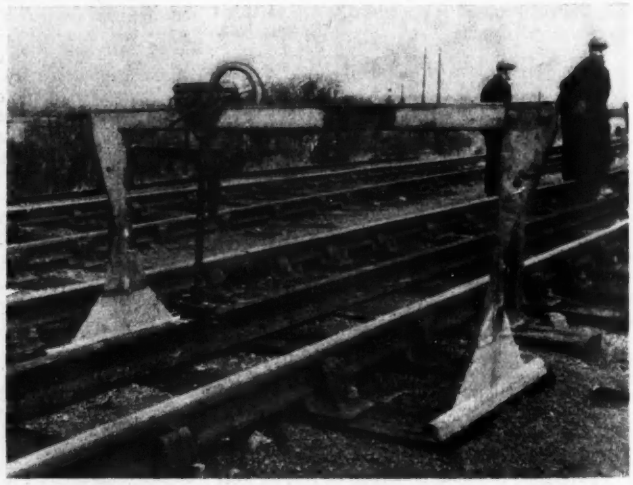
NEW methods and equipment have been introduced on the Southern Region of British Railways in order to speed up the renewal of conductor rails and reduce the amount of labour involved. Under the new system it is possible to unload the maximum length of rail and place it in position quickly with the minimum amount of effort with relatively small gangs of men. The new methods and equipment were evolved under the direction of Mr. F. E. Campion, civil engineer of the Southern Region.

Train of Welded Conductor Rails

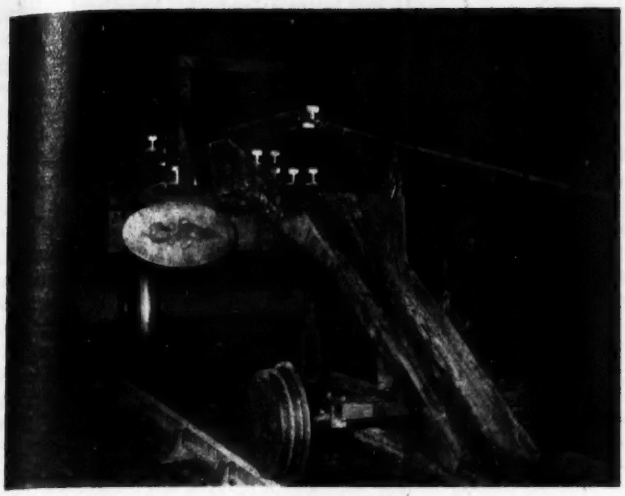
Before these methods were introduced it was necessary for conductor rails, supplied generally in 60ft lengths, to have four holes drilled through the foot at each end to receive the plug terminals for the heavy copper bonds by which the rails were coupled electrically. These holes were drilled undersize if the rails were not intended for immediate use, and the holes were reamered out to the full size shortly before the rails were laid. During the relaying operation and after the rails had been placed on the new insulators, the bond holes were cleaned by wire brushing, after which the bonds were inserted and the terminals expanded by means of a hydraulic press. The rails were then fished up.

Under the new system, which was introduced last year, 150 lb conductor rails are welded up into 180ft lengths at the flash-butt welding depot at Redbridge, Hants, and the bond holes at each end drilled. These rail lengths are then conveyed to the site on rakes of three 40-ton bogie wagons, or on old carriage underframes which have been specially converted for the purpose. At the depot up to twenty-six conductor rail lengths are loaded on to the wagons in four tiers of eight, seven, six and five rails. These rails are chained tightly to the wagon at one end and loosely at the other end. A third chain loosely encircles the load at the middle of its length. Each tier of rails is separated by steel straps, the turned-up ends of the straps being bolted together to form frames through which the rails above can slide freely without the risk of their slipping off the lower tier. A train of wagons loaded in this way can negotiate curves as sharp as 5 chains without difficulty. The way in which the load of rails adapts itself to the curvature of the track can be seen in the photograph of the train we reproduce on this page. The rail train also carries the equipment used for the end off-loading of the rails. This equipment includes a simple wire rope pulling-off tackle with a quick-release hook, and a chute fitted with a pair of trolley wheels.

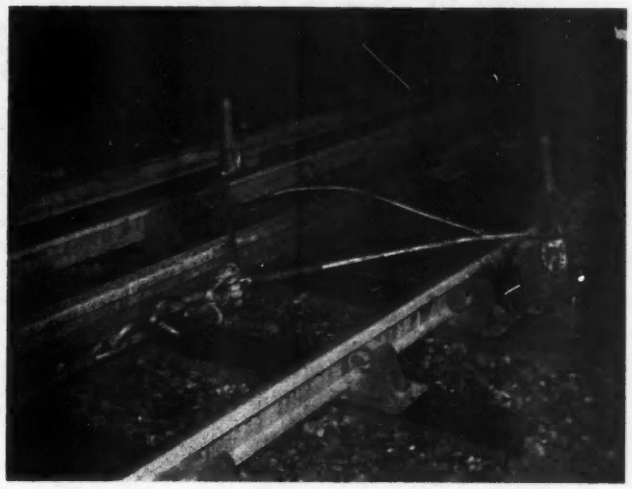
When the rail train arrives at the site the chute is assembled and attached to the headstock of the trailing wagon, and one end of the wire of the pulling-off tackle is made fast to the track. The chute and the simple way of anchoring the



Rail Lifting and Traversing Frame



Rail Chute on Wagon End



Pulling Off Tackle

wire rope tackle to the track can be seen in the illustrations above. Wooden blocks are used to prevent chafing of the rope on the rails. The other end of the wire rope is fastened to the end of the rail to be unloaded, and the train is then pulled forwards from under the rail. Specially shaped steel straps are used to protect the ends of the rails in the tiers from abrasion as the rails above are pulled off. A light angle-iron portal frame bolted to the end of the wagon guides the trailing end of the rail on to the chute down which the rail slides, to come to rest without shock or distortion on the sleepers in the 4ft way.

As each length of rail is unloaded the pulling tackle is released and carried forward ready to attach to the next position in the track for the next rail to be unloaded. We are informed that by this method a gang of only six men can unload 1½ miles of conductor rail in 4½ hours.

For laying-in purposes the conductor rails are jacked up and skidded across to their final line over the insulators, any correction required in their longitudinal position being assisted by roller blocks before the bonding and fishing-up is completed.

One of the appliances which has been devised to simplify and speed this operation of transferring the rails from the 4ft way on to the insulators is shown in another of our illustrations. This appliance consists of a simple frame structure on the top member of which runs a carriage supporting a 1½ tons capacity lever-and-chain-operated hoist with an attachment for gripping the rail head. On each 180ft length six of these lifting and traversing frames are used to lift and position the rail on its insulators, without call for any special device for "inching-up" longitudinally. Using the frames sixteen men can complete the laying-in, fish-plating and bonding of ½ mile of 150 lb conductor rail in 4½ hours.

We are informed that when an adequate supply of special anchor insulator units and expansion bonds becomes available, it is proposed to shape the ends of the 180ft rails at the welding depot and to join them by electric arc or oxy-acetylene welding at site. This will produce continuous rail lengths of ½ mile and enable a saving of ½ ton of the copper used in bonds per mile.

Preserving Historic Machinery

AT a meeting of the Newcomen Society, which was held in London on Wednesday last, a paper entitled "The Preservation of Historic Machinery and its Problems" was presented by Mr. A. Stowers, M.I.Mech.E. In the course of the paper Mr. Stowers said that heavy machinery of historic importance which was preserved, or which ought to be saved, usually fell into one of the three following main groups: mills, engines and machines which were preserved on their original sites owing to specially favourable conditions or because their weight and size made it impracticable to move them; mills, engines and machines which had to be moved to other sites for safety but were still preserved out of doors; and machines and engines preserved inside museums and other buildings.

In connection with the last group, Mr. Stowers referred to the new industrial museum in Birmingham, which, he said, owed its foundation largely to the Midland branch of the Newcomen Society working in conjunction with the Birmingham Common Good Trust. A survey of items of engineering historical interest in the six Midland counties, made by Mr. W. K. V. Gale, had brought to light some interesting old machines, and a few of them were now in the museum at Birmingham, of which Mr. N. W. Bertenshaw was the keeper. Already there had been installed some examples of heavy machinery, including one large beam engine with A frames; two smaller beam engines; a tilt-hammer about 150 years old from Messrs. A. and F. Parkes, driven by a waterwheel until 1951, with a guillotine worked off the same shaft; and a diesel engine of 1901. The museum also had Murdock's original model steam locomotive, examples of Boulton's products, a complete gallery containing a very fine collection of small arms, and other galleries with old and new electrical apparatus and telephone equipment manufactured locally.

In another part of his paper Mr. Stowers mentioned two examples of preservation where complete buildings and their machinery had been moved. A few years ago, he said, the National Museum of Wales, at Cardiff, received from the Earl of Plymouth the gift of St. Fagan's Castle with 18 acres of land, about 4 miles west of the city. In 1948 St. Fagan's was opened as a Welsh Folk Museum, and one of the buildings in the park was an eighteenth century woollen factory, which had been dismantled and transported from Breconshire and rebuilt on its new site. The second example, Mr. Stowers continued, was the Blaise Castle House Folk Museum, which was opened in 1949, and which was the responsibility of the Bristol City Museum. For the construction of a new reservoir in the Chew Valley, 8 miles south-east of Bristol, various buildings had to be submerged, but the Bristol Waterworks Company had presented to the city an eighteenth century Stratford water mill complete with dam and sluice gates. The mill had now been re-erected in the park surrounding Blaise Castle.

The final part of the paper dealt with some of the problems related to the preservation of historic machinery. Mr. Stowers said that the problem of preserving more original locomotives was a very difficult one owing to the space required, the cost of new buildings, and the fact that locomotives were often considerably altered and rebuilt with new parts during their working life, so that preservation of the originals were practically impossible. It was frequently assumed that there must be suitable empty spaces in locomotive running sheds or in sidings, but the problem of access by the public was a serious one, and railway enthusiasts of all ages could not be allowed to wander across main lines. The building of suitable sheds and bridges meant extra expense at a time when British Railways were being hard pressed to effect economies. To enable the student of railway history to study the continuous development through one and a half centuries and to fill existing gaps, the practical solution was to make scale models, all to the same scale, from original drawings if they still existed, and to paint them in their original attractive liveries. A report to that effect had recently been submitted to the Railway Executive and was now under consideration.

Mr. Stowers added that the problem of showing original exhibits, especially in engineering, was getting more difficult in any museum. In view of insufficient exhibition space at the present time, large storage space was essential. This should be treated as reserve collections and should be available for inspection by suitable applicants. Special museums had already been founded which were devoted to one subject, e.g. aeronautics, road transport, &c., and that plan might have to be more widely adopted. At present the policy in the Science Museum, as in most others, was to mix original exhibits with scale models and that was the most practical solution, provided there was adequate space. But the display of original exhibits like locomotives, aircraft, motor-cars, steam turbines presented grave difficulties in a museum owing to space, weight and handling problems. The display of original ships and civil engineering was virtually impossible in a museum. On the other hand, a collection of scale models only, either to a uniform scale or a mixture of scales, as was more usually the case, was inadequate and did not give the right perspective or atmosphere. The goal to aim at, and the museum building should be suitably designed for it, was to illustrate a period of development by an original machine with a group of models round it. The long narrow galleries which were seen in many museums were not ideal, though they were often unavoidable owing to site limitations.

Finally, Mr. Stowers said that there should be much more co-operation between museums in this country, which collected historic machinery, and interested institutions and societies, to make the best use of the limited national resources of money, space, buildings, &c., now available.

THE LUBRICATION OF BALL AND ROLLER BEARINGS.—A new booklet entitled "The Lubrication of Ball and Roller Bearings," is now being distributed by the Hoffmann Manufacturing Company, Ltd., of Chelmsford, Essex. This booklet, which has been written by Mr. T. S. Nisbet, the assistant chief designer of the firm, deals in some detail with the objects of lubrication; the advantages of grease for ball and roller bearing lubrication, and the choice of suitable greases; the correct way to grease bearings and the design of housings to provide effective grease lubrication; oil lubrication of ball and roller bearings and its application; and oil-retaining closures. Designers and users of equipment fitted with ball and roller bearings will find much useful guidance on the very important aspect of lubrication in this book.

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ESTIMATES FOR THE FIGHTING SERVICES

The publication of the Estimates for the Fighting Services in addition to the Defence White Paper, which we reviewed last week, now makes it possible to measure the extent to which the original £4,700,000 three-year rearmament programme has been curtailed and reorganised as the result of the economic situation and the development of new kinds of weapons and equipment. Including £225 million of economic aid from the United States during the current and forthcoming financial years, the total expenditure on defence over the three years will amount to £4281¾ million, of which £1636¾ million is the estimated expenditure for 1953–54.

Of the three Services, the Navy—with total Estimates amounting to £364½ million—is the least affected by the shift in priorities, though the Government's decision to prevent any substantial rise above the level of expenditure on defence production during the current year has inevitably entailed some postponement of contracts for new vessels. But there have been no cancellations except for a hospital ship and two fleet tankers. The naval programme is indeed in no sense rearmament, but an urgent requirement to enable the Royal Navy to defend our sea communications against the submarine and mine threat. Prototypes of suitable anti-submarine and minesweeping vessels were available in 1951 and the programme merely provided for the construction of as many of these ships as practicable within the three years, in addition to speeding up the completion of the carriers and destroyers which have been building at a snail's pace since the war. In spite of the steel shortage, good progress has been made, and already thirteen of the twenty-four frigates planned and ninety-five minesweepers are under construction. Some twenty of the forty-five destroyers to be converted to anti-submarine frigates are also in service or nearly ready for service. Britain is indeed fortunate in having a large number of small shipyards not swamped with orders for merchant ships which are able and anxious to build small warships such as coastal and inshore minesweepers. None the less, all this new construction is entirely for defensive purposes. No beginning has yet been made with the rebuilding of British seapower—the power to carry out a sustained offensive in enemy waters. Not one large ship has been laid down since 1945, and the three powerful "Defence" class cruisers, begun during the war, still lie unfinished, awaiting a decision on their armaments.

Both the Army and Air Estimates—£636 million and £548 million respectively—reflect the gathering momentum of rearmament, in spite of the enforced check on production. Army Estimates are up by £51,000,000 and Air Estimates by £80,000,000 on the provision for the current year. The Secretary of State for War, in his memorandum accompanying his Estimates, gives an informative and very interesting account of the Army's tasks and duties in the various theatres of the hot and cold war. His memorandum indeed provides a complete answer to the demand for a reduction in the period of National Service, for even with a present strength of the equivalent of 11⅓ divisions, the Army is seen to be stretched to the limit in meeting our oversea commitments. Mr. Head again gives just praise to the Centurion tank, which is now available in adequate numbers for the active Army, and is to be supplied to the Territorial Army for training during the coming year. There is, however, still no news of a more modern tank which, for some time past, has been reported to be in the prototype stage. The Estimates refer to a new scout car and a new armoured wheeled personnel carrier in full production, and to the development of a new assault floating bridge and a new heavy assault ferry. There is also mention of several new types of weapons and missiles, including an anti-tank grenade which is projected from the standard rifle and weighs only 21 oz, but has a destructive capacity equal to the most powerful infantry anti-tank gun used in the last war. A recoilless anti-tank gun is to replace the existing heavier and less easily manœuvred gun and the United States 3·5in rocket launcher has been adopted for the infantry platoon. All these weapons are in full production and are being issued to the troops. Finally, production is being started on body armour of American design and on a range of instruments to detect the presence of radio-active matter. The Air Estimates inevitably lack interest for the general reader because of the procedure now in force of informing the public as soon as the prototype of a new aircraft is in existence. And as aircraft are missile carriers rather than self-contained units of an armed force, the Secretary of State can give no more than a vague general idea of the progress in equipping the Royal Air Force with new machines. "Preparations have been made to bring the 'Swift' into squadrons as they become available"; "the expansion of the 'Canberra' bomber force will be greatly accelerated" are possibly all that can be said on security grounds, but such statements are not calculated to rouse the reader's interest. None the less, under the super-priority scheme and as the result of the generosity of the United States and Canada in providing "F 86 Sabres," it seems that both Fighter Command and the Second Allied Tactical Air Force on the Continent are at long last being equipped with fighters and fighter-bombers of the latest types.

All three Service Ministers give better news of their manpower problems. The First Lord reports a considerable improvement both in re-engagements of senior ratings for pension and in the recruiting of naval air crews. The Secretary of State for War refers to the striking success of the recently introduced scheme of twenty-two years' colour service, with the option of leaving at the end of each three-year period. Total regular recruitment from all sources, including short service engagements, was 53,226 in 1952, compared with 26,372 in 1951, but Army units as a whole are still 3000 officers and 5000 other ranks below their full requirements. The Royal Air Force has no overall shortage, but has a serious deficiency of highly skilled men in some of the more important trade groups. New recruits and men already in the Royal Air Force still seem reluctant to enter into engagements for five or more years or to re-engage for pension.

ENGINEERS AND STEEL CASTINGS

At last Friday's discussion at the Institution of Mechanical Engineers of a paper on "Developments in Steel Castings in the Heavy Power Plant Industry," Mr. Twynham suggested that "a lot more trouble" was experienced to-day by users of steam turbine castings than, "say in 1937–38." That remark, no doubt, is true enough. But if applied to a wider field it does not accord with our memory of the inter-war period. Indeed, in our recollection, between the wars many engineering designers and production people were ready to say forthrightly, if asked, that only the simpler steel products could be satisfactorily cast in this country, and that for more complex structures it was necessary to place orders on the Continent. It is, in fact, our impression that doubts about the serviceability of steel castings were at that time actively encouraging manufacturers to find alternative means of construction, either by so altering designs or conditions

that cast steel could be eliminated or by developing built-up welded procedures. It is true that many troubles are still experienced with steel castings to-day. But much has been learnt by British founders in the interim. If defects seem to be found more frequently than before they are at least now found at an earlier stage; for inspection procedures have been improved. Moreover, there are now also available improved methods of rectifying defects. Steel castings have surely become more, not less, reliable.

Nevertheless, the discussion at the Mechanicals clearly revealed an underlying conflict between designers and users, on the one hand, and founders, on the other. For each tended to blame the other for unsatisfactory castings. That conflict is to be expected. It arises out of the paradoxical situation that it is, of course, because the shape of a part is intricate that casting is chosen as the means of forming it, whereas the more intricate the shape the greater the difficulty of making a satisfactory casting. Nor is it at all easy for a steel founder to say with certainty how difficult it will be to make a casting to a given design until he has tried. Many a designer, in part appreciation of a founder's problems, has offered, in sending along a blue-print, to make modifications that would simplify casting. Many a founder looking at such a blue-print has believed that the shape can be cast without undue difficulty. But, all the same, it is quite likely that the designer who was so willing to co-operate will eventually have to be told, when the castings turn out to be defective, that the shape is, in fact, difficult or even, perhaps, impossible to cast. For casting, and more particularly steel casting, is still very much more an art than a science, despite the research work that is being done by the British Steel Founders' Association. That is why Mr. Buckley, the author of the paper, stressed the desirability of concentrating the production of large and complex castings such as those for power plants "in as few foundries as possible, so as to facilitate the building up of practical experience." It is, too, no doubt, the reason why certain Continental foundries are able to make particularly well certain specialised types of castings of which they may have had experience for twenty years or more. Of course, it must be the responsibility of steel founders to decide whether a particular design of casting can or cannot be cast successfully. Yet it is not an easy thing in a competitive industry for a founder to confess that he cannot undertake to make a satisfactory casting. Besides, as Mr. Capper remarked in the discussion, founders may tend to regard a design as a challenge to their ability. Nor do we think it by any means undesirable that founders should sometimes take on jobs that may prove beyond their capacity to cast satisfactorily. For engineers are continually asking more of the materials they use and unless progressive founders are prepared to risk their reputations in undertaking jobs that they know will tax their ability to the utmost and possibly beyond it, how is improved knowledge to be gained and how are new methods to be evolved? It is, after all, the difficult jobs that inspire men to undertake research and to originate advances in practice.

But if the responsibility for rejecting a design as unsuitable for casting must rest with the founder, the designer of the casting cannot escape all responsibility if castings have defects. In the pouring, solidification and cooling of a casting certain unalterable natural phenomena occur. In designing a satisfactory casting those natural phenomena must be taken into account in just the same way as other phenomena influence the design of turbine blading or the arrangement of tubes in a boiler. Too often, founders complain, they are not taken into account, and in defence against the complaints of users of steel castings, Mr. Rowe declared roundly in the discussion that "in the utilisation of modern metallurgical and physical knowledge governing the design and production of such castings the knowledge and scientific approach of the steel founder is far, far ahead of that displayed by the designer." Various publications by the British Steel Founders' Association in this country and the corresponding body in America are designed to correct that situation. There are other activities, too. From April 15th to 17th, the B.S.F.A. is organising a Convention in London which is intended to bring founders and designers together and to demonstrate to the latter by means of suitable exhibits what are the particular complexities of design likely to give trouble. The discussion at the Mechanicals emphasised that instead merely of complaining to steel foundries when castings turn out to be faulty, engineers would do better to consult with them to see whether modifications of design would ease casting problems, or whether techniques such as the welding together of separate cast parts would simplify casting procedure. The casting of iron is easier than that of steel. Yet one of the reasons why iron castings have become so reliable may well be that an iron foundry is often a constituent part of an engineering works, so that the designer is brought intimately into contact with its problems. But steel foundries are much less commonly associated with engineering works. There is all the more reason, therefore, that designers should go out of their way to inform themselves about steel casting techniques and problems. The work that the B.S.F.A. is doing to help them is to be applauded. The design of a steel casting is a matter for co-operation between founders and designers both of whom need to compromise to get the most satisfactory results.

Letters to the Editor

(We do not hold ourselves responsible for the opinions of our correspondents)

LIBRARY SERVICE FOR INDUSTRY

SIR,—I have read with considerable interest Mr. K. J. Rider's article on "Library Service for Industry," in your issue of February 13th. Whilst there is much in it with which I would unhesitatingly agree, I feel that I must take issue with him over one small point. In his first paragraph he states that "The activities of an information department usually revolve round the library." This is a popular belief amongst librarians, but it is a fallacy none the less.

It seems fairly evident from numerous remarks throughout the article that Mr. Rider's experience is limited to technical information departments. In that field his generalisation may well be true. Had he had some experience of non-technical information, or intelligence departments in industry, however, he would not perhaps have been quite so dogmatic about the position occupied by the library. The boundaries of information or intelligence work are difficult to define, but wherever they are drawn various stages of intelligence work can be distinguished. They range from the routine supply of factual information at one end to evaluation and giving of advice in policy formation at the other. In the former the techniques of the librarian, namely, collecting, storing and disseminating information, are all important. In the latter they are of insignificant importance.

It is probably true that technical information departments rarely reach into the higher stages, for the work of evaluation is undertaken by the technical personnel for whom the library exists to serve. On the commercial, industrial and economic sides, however, the work of evaluation is often undertaken and in information departments of this type the library may be relatively unimportant, or even non-existent. I have some experience of a large intelligence department covering technical, commercial, industrial and economic matters, in which the library is only one section among several. I know of other organisations in which the library is part of a technical information department and commercial information is under an organisationally separate department.

By all means let librarians advertise the very valuable services they can render to an industrial firm. But do not let those librarians whose experience is limited to technical information departments imagine they are the hub of a wider universe covering all types of information work. The higher function of evaluation, often undertaken in non-technical information work, requires a type of training and qualities of mind quite different from those necessary to the collection, storing and dissemination of information. In the well-knit, comprehensive information department, both the documentation and the evaluation aspects are important, and they supplement each other. But in no sense does such a department revolve round the library. It is time that this popular misunderstanding among librarians, which Mr. Rider seeks to keep alive, died a natural death.

A. R. SMITH

Wimbledon Common, S.W.19,
February 25th.

DIMENSIONS ON DRAWINGS

SIR,—I frequently wonder at the lack of uniformity amongst engineers in the way that drawings are dimensioned.

One frequently sees on the same drawing some dimensions figured in inches and some in feet and inches.

This must often be the cause of mistakes in the shops, which could be avoided if it were an established rule for all dimensions of 12in and under to be figured in inches and all dimensions over 12in to be figured in feet and inches.

It would be a good plan if draughtsmen were instructed to this effect.

GEO. E. ASBURY, M.I.Mech.E.

Newark-on-Trent, February 24th.

TUBULAR STRUCTURES FOR RAILWAY ELECTRIFICATION

SIR,—In your issue for February 13th, a letter appears from Mr. J. C. Read, commenting on the description of the prototype tubular structure for railway electrification, which was published in THE ENGINEER for January 23rd, and referring to alleged difficulties in preventing internal corrosion of tubes.

As the pioneers of modern steel tubular construction and the largest firm engaged in this work in Britain, it is a cardinal principle in our practice to ensure that all tubes are properly sealed so that no internal corrosion can take place. Even in the case of tubes such as lighting standards and tramway poles with only a cast iron finial inserted in the top, original mill scale and

internal tool marks are visible after service up to forty years.

We do not know where the particular tubular overhead line structures, which Mr. Read saw being dismantled, were located, but it is obvious to us that no attempt can have been made to seal the structures, which may easily have been made from scrap tubes used in the absence of new material.

We know of no extensive railway electrification scheme using tubular construction except on the Italian State Railways, where many of the original structures are still in service after twenty to thirty years.

E. McMINN
Chief Engineer, Tubewrights, Ltd.
London, S.W.1, February 25th.

Literature

SHORT NOTICES

Examples of the Design of Reinforced Concrete Buildings. By C. E. Reynolds. London: Concrete Publications, Ltd., 14, Dartmouth Street, S.W.1. Price 10s.—The text, designs and calculations of this work conform to the British Standard Codes of Practice for Buildings (the relevant codes are listed) and are intended to explain and exemplify these codes. Part I of the book is of general application and starts with chapters on loads, permissible stresses, and so on, and continues with notes on the design of the various elements of a reinforced concrete building, including the foundations. In Part II the calculations and drawings for the design of a typical building are given.

Les Engins Mecanique du Chantier. By A. Gabay. Lausanne, Switzerland: Libraire de L'Universite F Rouge and Cie S.A., 6 rue Haldimand.—This volume, which is in French, is a detailed compilation of the principal sorts of excavating and earth-moving machinery at present in use on public works sites. A considerable amount of information is given about each sort of plant, the operating principles being described and illustrated. There are many tables and illustrations elucidating methods of operation, output of various sizes of plant and equipment, specimen calculations concerning various points of plant operation, and notes on the cost of operation with various sorts of plant. A comprehensive account of excavating machinery and various other sorts of earth-moving plant, such as tippers and graders, rammers, and so on, is given.

BOOKS RECEIVED

Road Engineering. By E. L. Leeming. London: Constable and Co., Ltd., 10–12, Orange Street, W.C.2. Price 30s.

Underpinning and Strengthening of Structures. By L. E. Hunter. London: Contractors' Record and Municipal Engineering, Lennox House, Norfolk Street, W.C.2. Price 25s.

B.R. 158 (52): *Examples in Electrical Calculations, Naval Electrical Department.* London: Her Majesty's Stationery Office, York House, Kingsway, London, W.C.2. Price 17s. 6d.

Marine Diesel Engines. By C. C. Pounder. London: George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 35s.

Mining Machinery. By Thomas Bryson. Third edition. London: Sir Isaac Pitman and Sons, Ltd., Pitman House, Parker Street, Kingsway, W.C.2. Price 35s.

An International Bibliography on Atomic Energy, Volume II. Scientific Aspects Supplement No. 1. London: H.M. Stationery Office, P.O. Box 569, S.E.1. Price 25s.

Television and Radar Encyclopædia. Edited by W. Maclanachan. London: George Newnes, Ltd., Tower House, Southampton Street, Strand, W.C.2. Price 30s.

The Composition and Assaying of Minerals. By John Stewart-Remington and Wilfrid Francis. Surrey: Technical Press, Ltd., Gloucester Road, Kingston Hill. Price 17s. 6d.

Mathematics for Telecommunications. By D. F. Spooner and W. H. Grinsted. London: English Universities Press, Ltd., St. Paul's House, Warwick Square, E.C.4. Price 10s. 6d.

Steel Castings

THE INSTITUTION OF MECHANICAL ENGINEERS

AT a meeting of the Institution of Mechanical Engineers in London, last Friday, February 27th, the following paper was presented and discussed :—

DEVELOPMENTS IN STEEL CASTINGS IN THE HEAVY POWER PLANT INDUSTRY

By F. BUCKLEY, B.Sc.*

Though the application of steel castings in the field of the prime mover is selected as a basis for treatment, the opportunity is first taken of mentioning developments inside the foundry that appertain to manufacture and inspection. The trend towards more stringent service conditions has augmented the responsibility of the foundry for the production of castings free from defects. There are indications that the designer and user of castings can with advantage pursue and develop the tendency to break down designs into relatively simple constructions that can be fabricated together at a later stage, and examples of this type of construction are given. Where this trend is impracticable, a strong case can be made for the concentration of allied types of work in relatively few foundries.

Mention is made of the trend of research as applied to steel castings, and the lasting importance of methods departments is stressed.

DISCUSSION

Mr. L. E. Benson, in opening the discussion, agreed with the author on the need for further discussion and co-operation between the design engineer and the foundryman and the need for investigating fully defects in castings at an early stage, i.e. in the foundry before heat treatment and before machining. The foundryman very often had the choice of alternative methods of moulding and feeding the casting and the method which would give the soundest and best casting was not always the method that gave the best-looking casting and one which was superficially most free from defects. They must be prepared, as engineers, to deal with defects when they turned up in a realistic way and not in a way which would embarrass the foundryman and lead him not to show up his defects openly. Even in the best foundries defects occurred and had to be remedied. An important feature of the paper was the part which dealt with the casting of intricate castings versus the welding together of simpler cast components. It would have been very interesting if the author had elaborated a little more on the factors which had to be weighed in balancing the risk of one construction against the risks of the other construction. The fact that foundrymen were beginning to wake up to the advantages of a scientific approach to their job—or at any rate a more scientific approach than the rather rule-of-thumb methods that had guided them in the past—was very encouraging and should lead to improvement in quality or at any rate a more even high standard of quality, in which case there would be less tendency to resort to difficult fabricated structures.

Of course, the fabricated structures had their own risks. It would be interesting to know whether the author could give his engineers the same guarantee of strength and creep characteristics in his weld metal as he could in, say, a molybdenum steel casting, i.e. a sound one. The fact that the author referred to some of the joints as being screwed and welded rather suggested that there was a doubt about this.

Dr. M. L. Becker said that if a higher strength was required than one would normally be able to get with, say, a normalised structure, recourse must be had to heat treatment, and he thought that possibly the author did not quite do justice to the heat treatment process in the paper. He asked the author to elaborate this matter a little and give some information on the sort of compositions he would consider for, say, a turbine casing; or for a Pelton wheel, where there was going to be no high temperature during service. If the casting was to respond well to heat treatment, of course, it must contain a fair amount of carbon—say, up to 0·3 per cent or 0·35 per cent—and then with some form of treatment an increased tensile strength could be obtained. It was perhaps not always recognised that, whereas a fair alloy content would be necessary in such a composition, it was possible to give local hardening to resist wear on leading edges and different places of such castings by the application of local heat treatment. Here again, modern developments were showing very great possibilities, and both by induction hardening or flame hardening a rather surprising wear resistance could be obtained in certain places. That applied to forgings, of course, just as much as to castings.

Mr. A. C. Annis said that the author's introduction to the paper was a clear and concise account of the race between the engineers' ascending requirements and the founders' technical developments. This race was international, with no favoured competitors except those whose use of steel castings in great quantities provided experimental experience at a correspondingly accelerated rate. Although in this, as in so many branches of engineering science, the metallurgist had notably met the engineers' functional requirements, the conversion of designs into cast physical shapes had been, and still was, to a considerable degree, a sad story from the users' point of view. The author's treatment of foundry production developments was reassuring and he had some knowledge himself of the very considerable and objective scale on which research and development work to improve this situation was being carried out by the British Steel Founders' Association. It was, however, in regard to the author's treatment of inspection procedure that he wished to make a contribution. The author rightly emphasised that improved standards of inspection did not mean increased scrap, but rather a more accurate determination of the possibilities of repair, and to this might be added, also, the determination of the causes of many defects for future elimination and considerable saving in the costs of repairs. The author had rightly said that it was desirable that the founders' visual inspection should be augmented by the use of one or more specialised methods ranging from chemical pickling to radiography and magnetic crack detection, in order to provide a complete layout of the defects. The considerable developments of X and gamma radiography apparatus were, he thought, a measure of the urgency of the problems which the author had presented so effectively. The application of the equipment now available and the interpretation of the indications obtained were not yet conclusive where unsymmetrical shapes were concerned.

Meanwhile, for a considerable period of time the opportunity had existed completely to expose the parent metal surface by acid pickling, and it had been demonstrated very conclusively that examinations which might appear in the dictionary sense to be

* Chief Metallurgist, The English Electric Company, Ltd.

superficial were by no means superficial. On the contrary, they pointed the way frequently to deep-seated defects of every known variety.

From many experiences it could be asserted that there were no completely sound steel castings produced in this country or elsewhere, and in this latter regard he spoke with some experience of American practice. It was clear that in the present circumstances all steel castings were repaired in some degree by the founders and far too frequently by the user. The great value of papers such as that now under discussion was in the opportunity afforded for frank discussion of the inherent problems of design and foundry technique such as demanded from all concerned—from designer to founder—a contribution to the solution of the problems which must lead to immeasurable benefits not only to industry but to the national economy also. Gone were the days, thank goodness, when these matters were buried in a catalogue of complaints from user to founder. To-day it was becoming well established and accepted that the steel founders' function was to insist on designs which were castable and thereafter to supply to the users sound, or at least fully repaired, castings. To this end the chain of individual specialist discussions of the past must give way to collective discussions round a table between the engineer, metallurgist, chief draughtsman, chief pattern maker and foundry manager, with scale models of critical castings in front of them, under the informed chairmanship of the user, who was the one individual who could not leave the matter on the table if he was to convert designs and castings into satisfactory power plant to satisfactory manufacturing schedules.

Mr. H. Capper spoke as a user, although he had some knowledge of the difficulties of the foundryman, too. Mr. Annis, being a user with similar experience, had shown that he had had some very bad castings to deal with in his time. The Engineer-in-Chief of the Fleet had also been very disturbed recently and, indeed, for some years, about the poor quality of castings ; and in this connection he wished to refer to the paper, where it was stated that " One criticism that can be levelled at the foundry industry is that far too often a difficult and complicated design is accepted without hesitation. In this respect it would almost appear that a fear exists that rejection of a design on the grounds of complication during the casting process would represent a reflection on the competence of the founder." There were two schools of thought on the question of the designer and the foundryman getting together. On the one hand, the designer rather considered that any sort of shape could be cast regardless of whether it had protuberances, bosses, widely different sectional thicknesses, and so on ; and in fact the designer often modified his designs and stuck a bit more on here and there and still expected a good sound casting to be obtained. On the other hand, the founder considered that anything was a challenge to him to produce a good casting, and rather than go to the designer and say that it was almost impossible to cast the design, he would turn out a bad casting and perhaps try to cover up any defects which he knew were there. Of course, much had been done recently to mitigate that situation, but he felt that what was being done was not general enough. Some of the more go-ahead founders in the country were very informed on this matter and they had methods of proper inspection before the casting left the foundry and got to the contractor or designer—so that it could be put right. He felt that the responsibility must be put at somebody's door and he believed that it should be the founder's door. The founder should be responsible for saying that he could not cast a thing and that some modification would have to be made. In that way, he thought, it would be possible to get better castings. It was the founder's responsibility to say if he could not cast a thing and not the designer's function to go to the founder first and ask whether it could be cast. Let the designer design as he wished, and then let the founder come back and say if it was impossible to cast and required modification.

Mr. F. Rowe said that one or two of the contributors to the discussion had spoken of the defects and deficiencies of the steel founder, but he would say pretty categorically that most steel castings that engineers got were as good as the design would let them be. In the utilisation of modern metallurgical and physical knowledge governing the design and production of such castings, the knowledge and scientific approach of the steel founder was far, far ahead of that displayed by the designer. There was a growing appreciation on the part of the steel founders and the British Steel Founders' Research Association that more and more education of the designer was obviously wanted, and they were undertaking that task as far as they could. For instance, within the next month there was to be a customer-designer convention to which they hoped to invite the designers who were responsible for the designing and ordering of steel castings to come and look at a collection of exhibits, with a view to their getting an appreciation of the difficulties with which the founders had to contend. At that convention the designers would listen to a very large number of metallurgists who were constantly engaged on these problems and who would try to persuade them that simply because a job was a casting one could not put any sort of metal thickness, any sort of shape, any sort of cross-section on it, and at the same time hope to get a casting which was metallurgically sound.

Dr. T. P. Hoar said that at Cambridge they had been studying burnt-on and its relation to metal penetration for some time, and he thought it might be interesting to point out that the fact of metal penetration was in a sense not a surprising thing. If one poured water on sand, of course, it went straight in ; and the steel founders were fortunate in having material that did not wet sand—and consequently steel founding was possible at all. But, of course, if one had a metallostatic pressure of the order of 1 yard upwards on top of the sand, one might force the metal into the interstices and get metal penetration and burnt-on. That was one of the natural difficulties and hazards that the steel founder making a large casting would always have.

The author had kindly said that mould paint was a clear method by which metal penetration and sand burnt-on might be prevented in large castings. It was perhaps necessary to sound a note of warning there. The slag type of mould paints were in a very early stage of development. The ones mentioned in a paper by himself and Atterton were hardly suitable for foundry use, consisting as they did of lime-silica mixes and of iron oxide-silica mixes ; but there were great hopes of a number of other types of slag mould washes, and it was hoped that in the future it would be possible to say that one might entirely prevent metal penetration and burnt-on. For the moment, he thought that perhaps the author took a little too optimistic view of the experiments.

Mr. H. Parkes remarked that the author said the trend of design was severely limited by the paradox that factors conducive to a sound and satisfactory casting called for relatively simple shapes, whereas the mere fact that the cast form was used in the first place implied complications in that direction. Could the author say which way he thought the trend was on balance—whether it was to get more complicated castings with the designer continually throwing harder jobs on the founder ?

Mr. Twynham said that the turbine designers were particularly interested in the paper, especially in view of the number of cases where the onus was placed on the designer to accept repairs for defective castings. He felt that, in the matter of steam turbine casings, in the past ten years there seemed to have been a lot more trouble than, say, in 1937 and 1938. The general tendency seemed to be that they were getting more trouble with steel castings since the war than before the war. What had really happened ? Had they lost the practical art of the old school, which had now been replaced, presumably, by highly technical metallurgical methods ?

The foundrymen were " getting at " the designers, but the fault was not always with the designer. On a number of occasions he had himself submitted designs of turbine casings to steel founders for their comments with a view to making alterations within reason ; but they had always said that there would not be any trouble in making a sound casting. That attitude might, of course, be due to competitive reasons. The author referred to inspection. He wondered whether the position was not that in the old days many of these faults had been there but had not been known to be there. Was it the case that people were now looking for things which they had not looked for in the past ? The founders must, however, appreciate that the designers were now faced, not with a temperature of 700 deg. and pressures of 300 lb and 400 lb, but with a temperature of 1050 deg. and a pressure of 1500 lb. They must, therefore, have sound castings, and this was where the rigid inspection which the author outlined would be very helpful. He thought it was true to say—and he thought the founders would agree—that the designers had in this instance tried to simplify the castings. There was, of course, certain mutual advantage to be gained from discussion and co-operation between the two sides, but at the same time it had to be appreciated that there were certain limitations on what the designer could give to the steel founder, and in the long run it must be a question of compromise. On the question of troubles in service, he thought it was true to say that a little bit of distortion took place and in certain cases there was cracking which appeared to the designer to be due possibly to insufficient stress relieving. The author referred in the paper to a soak of about fifty hours and the designers felt that it was imperative that there should be this fifty hours' soak. The thing that really troubled designers was the presence of core, iron scale, and so on, which the founders tried to remove but did not remove ; and if they got left in and were not noticed, they would break a road through and get in the turbines—and it would be just too bad for the designer and the customer. Collaboration between the designer and the steel founder would be helpful particularly on the question of getting access for cleaning nasty cores out.

Mr. H. Smith, in defence of founders, felt it right to say that the improvements

over the last five or ten years with modern methods of inspection had certainly improved the castings. As regards design, surely by the time the designer had designed a casting and submitted it to the founder to be made, there was not sufficient latitude allowed for the founder to carry out any serious alteration, and the small alteration of design usually permitted was usually not anywhere near enough for what the founder wanted, particularly when it came to a junction between flange and body thickness, for instance.

Dr. H. E. Davies said that it was very satisfactory to learn from the author of the efforts that he was making to effect improvements in the technique of manufacturing steel castings, since the quality of these items had caused the British Electricity Authority some considerable concern in the last few years. This might be due to the fact that they had taxed the resources of the foundries rather too severely in their efforts to make up the shortage of generating plant as rapidly as possible, but there was no doubt that delays had been caused due to the discovery, often at a late stage in machining, of unsound castings, very often on large items like turbine covers. He must agree with the author when he said that the design of such castings as turbine cases had become extremely intricate, and to ensure soundness in the material every effort should be made to break down such items into several components which could ultimately be joined together by welding. The turbine designer, however, was not an expert on steel casting, so that when he submitted his complicated design to the founder, the latter should take it upon himself to point out the difficulties he would experience in casting it. How often was this done ? In the B.E.A. they had had the opposite experience, in that when the steel founder had been assailed with the fact that he had made an unsound casting, he had replied to the effect that one could not but expect it to be unsound when it was so intricate, although he had been given the opportunity of expressing this fact when the design was originally submitted to him before he made the casting. Was it, as the author suggested, a fear that this would have been a reflection upon his competence ?

The author had dealt with the moulding and casting techniques necessary to produce as sound a casting as possible, but even so, he thought that the author would admit that there would still be defects, perhaps only occasionally, which would require rectification. Could the author give his views on rectifying faults by welding ? Although the very best techniques in moulding, casting, stress-relieving, &c., were carried out by the foundry so as to produce as perfect an article as possible, they still got the casting that cracked in service after one or two years' operation, for no apparent reason. The B.E.A. had had three recent instances of turbine cases cracking in this fashion, longitudinally right through the H.P. cylinder, about 4½in of metal, for a length of some 9in to 12in. Could the author say why castings should do this and whether he could stop them ? Was it due to residual stresses which did not get removed by annealing, or could it be due to operational stresses ? In B.E.A. they had had many instances of this type of cracking in valve bodies, manifolds, &c., which nearly always resulted in serious loss of output due to enforced shut-downs, but when they discussed them with the manufacturers they never received a satisfactory reason as to why an apparently sound casting should fail in this fashion.

Mr. F. Buckley replied shortly.

The Renault Gas Turbine Locomotive

Tests have been carried out in France of a new gas turbine locomotive built by the Régie Nationale des Usines Renault. Details of the design and construction of this locomotive and its trials were given in a paper by M. Fernard Picard before the Société d'Encouragement pour l'Industrie Nationale, on November 13th last. The description of the locomotive given in this article is based upon the information given in Monsieur Picard's paper.*

LAST year the first gas turbine locomotive to be designed and built in France was completed at the works of the Régie Nationale des Usines Renault and underwent a series of running trials on the French National Railways. This new locomotive is designed to develop 1000 b.h.p. and is carried on two two-axle bogies. It weighs 57 tons in full working order and has two speed ranges, one giving a maximum of 71km per hour and the other 125km per hour.

The design of the power unit used in the locomotive is based upon developments made by two companies—Société d'Etudes Mécaniques et Energétiques and Société Industrielle Générale de Mécanique Appliquée—and it consists of a " free-piston gasifier " which provides the power for driving a 1000 b.h.p. Rateau gas turbine. This free-piston gasifier is a further development of the Pescara design of compressor, which, as is now generally known, consists of a double-acting diesel engine arranged centrally in line between two air compressor cylinders, and having its opposed pistons connected to the compressor pistons. In the arrangement used on the locomotive the gasifier is adapted not only to supply its own scavenging and feeding air, but to use the exhaust from its diesel cylinder to drive the gas turbine. The diagram we reproduce in Fig. 3 shows graphically the arrangement of the gasifier and turbine.

It is pointed out that the thermodynamic cycle of the free-piston gasifier is between that of a diesel engine and a gas turbine. The power required for the compression of the scavenging and feeding air is produced by the gasifier itself by the expansion of gas in the diesel cylinder. The exhaust gas from the cylinder, at a temperature of about 500 deg. Cent. and a pressure of 3kg per square centimetre, is expanded in the gas turbine. Thus, the fall in temperature of the gas from some 1800 deg. to 500 deg. Cent. in the engine cylinder during the firing stroke is used for compressing the air and the further drop from 500 deg. Cent. to the gas turbine exhaust temperature is used to generate mechanical power.

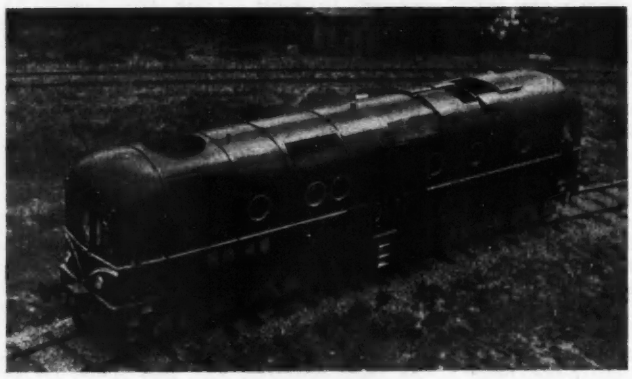


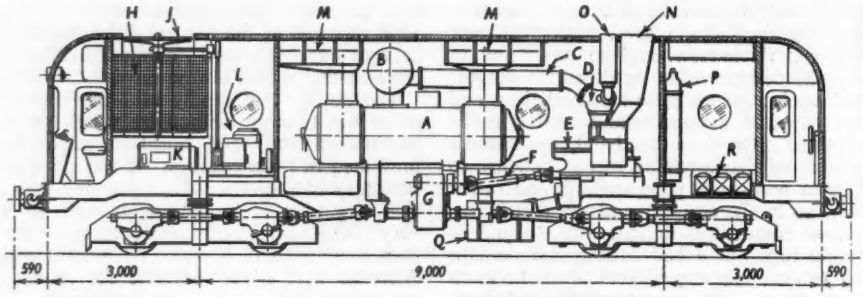
Fig. 1—Gas Turbine Locomotive

When compared with that of the diesel engine, this cycle is distinguished by the higher supercharge of the cylinders and by the elimination of any rod linkage. At full load the supercharge reaches pressures of 3kg to 4kg per square centimetre. This new design of prime mover thus only retains the essential part of the diesel engine—the variable pressure combustion chamber. Compared with the conventional gas turbine it substitutes the constant pressure combustion chamber for a high temperature and variable combustion chamber, of which a material portion of the output is used before the gas enters the turbine, so that the blades of the turbine work under much less severe conditions.

The flexibility of the plant and the possibility of getting a high starting torque allowed the use of an efficient mechanical transmission of simple design between the turbine and driving wheels of the locomotive.

The drawing reproduced in Fig. 2 on this page shows the arrangement of the principal units in the locomotive. Its all-metal body is mounted on a welded steel plate frame and, in keeping with general practice, there is a driver's cab with duplicated controls at each end. Each bogie consists of a welded-plate

* Head of the Engineering and Research Department of the Regie Nationale des Usines Renault.



A—Gas generator.
B—Gas reservoir.
C—Gas intake trunk.
D—By-pass valve.
E—Gas turbine.
F—Transmission shaft from turbine to gearbox.
G—Reduction, reverse and two-speed gearbox.
H—Oil and water radiators.
J—Fan.
K—Auxiliary diesel engine.
L—Service units, compressors, pumps, &c.
M—Air filters.
N—Turbine exhaust.
O—By-pass exhaust
P—Compressed air cylinders for starting.
Q—Fuel oil tank.
R—Batteries.

Fig. 2—Arrangement of Gas Turbine Locomotive

frame with a central plate and two lateral bearings which support the locomotive chassis. These bearings are designed to damp by friction transverse oscillations of the body during running. A combination of laminated and coil springs is used in the suspension system.

Air for the gasifier is drawn through plate filters in the roof sides. The hot gas leaving the gasifier passes into a reservoir, which acts as a delivery regulator, and thence through a duct to a by-pass valve which controls the turbine inlet. After its passage through the turbine the gas flows through a baffle box and opening in the body roof to the atmosphere.

The gasifier is designed to deliver, without

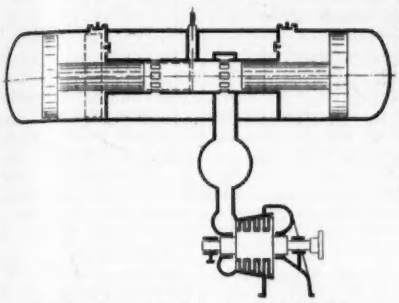


Fig. 3—Diagram of Gasifier and Turbine

supercharging, a hot gas output equivalent to 1200 c.v.* Its cylinder is jacketed for water-cooling purposes and its pistons are cooled by a circulating oil system. Fuel is injected by six injectors spaced round the cylinder wall and mounted in an annular steel body. The unit is fitted with a compressed air starter and the pressure in the cushion cylinder is regulated by a governor in accordance with the speed.

The diesel cylinder has a bore of 340mm and the compression cylinder bore is 900mm. At full load, when the exhaust gas is delivered at a pressure of 3·5kg per square centimetre, the average stroke is 450mm and the engine makes some 600 cycles per minute. In the course of

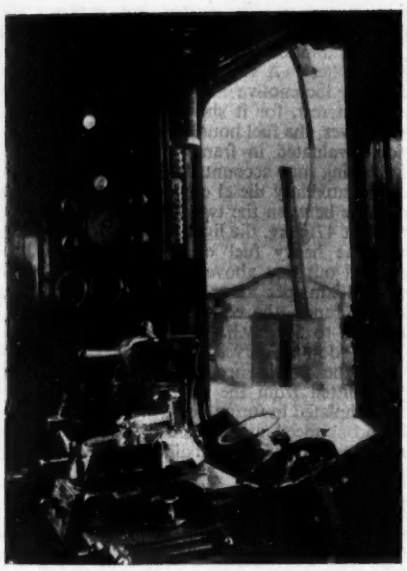


Fig. 4—Driver's Controls

bench tests it was found that with an average stroke of 415mm an average piston speed of 8·3m per second and a peak compression pressure of 60kg per square centimetre, the gasifier gave a flow of 3·56kg per second of hot gas at 475 deg. Cent.—corresponding to an output of 1200 c.v.—to the turbine.

Power is transmitted mechanically from the turbine to the axles and the turbine drives directly over its full range of speeds and full range of loads. In order to give the highest possible torque at starting, the turbine is built with a six-disc rotor. Its maximum permissible speed is 12,320 r.p.m., which, it is stated, corresponds to 145 per cent of the speed at maximum

* 1 c.v. = 0·986 h.p.

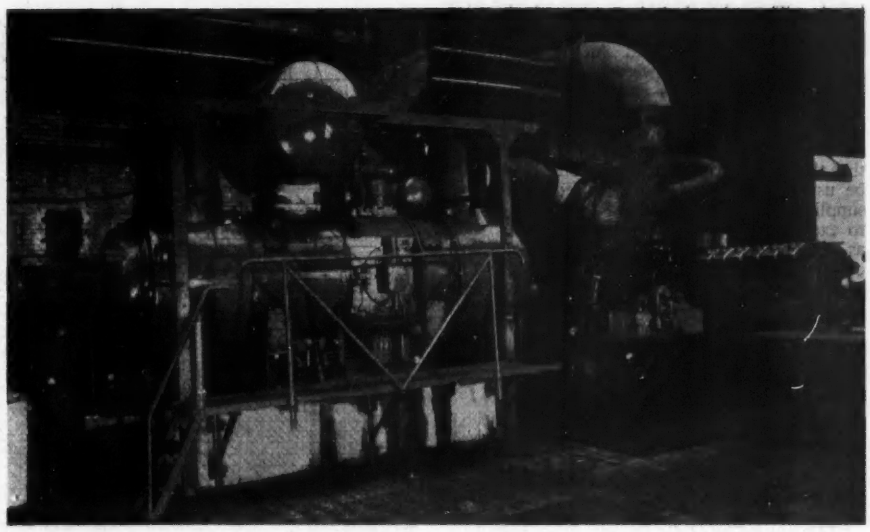


Fig. 5—Power Plant on Test

turbine output. A cut-out governor is fitted to reduce the fuel intake when the turbine speed exceeds its rated maximum. A 6·25 to 1 ratio reduction gear is driven directly by the gas turbine rotor shaft.

From the reduction gearbox of the gas turbine the drive is transmitted by shafts fitted with universal couplings to an intermediate power transmission and reduction gear unit set centrally below the locomotive frame. This unit incorporates a reversing gear and a two-speed gear arrangement in which two pinions on the main shaft are in constant mesh with gear wheels on the final drive shaft. A dog clutch operated by remote pneumatic control from the locomotive cab is used to engage the gear train of the required ratio. With this arrangement the two different speed ranges made available can be selected in accordance with the service conditions required for the locomotive. When using the lower gear ratio the locomotive has a top speed of 71km per hour and with the higher gear ratio a maximum speed of just under 125km per hour. Using universal couplings at each end of the output shaft of the intermediate gear unit the drive is transmitted by means of shafts to bevel and spur double reduction gearboxes on each of the bogie axles. The transmission boxes on each pair of driving axles are coupled together by shafts fitted with universal joints. As the shafts transmitting the drive from each side of the central drive unit are of the same length, the torsional strains are equally distributed. A brake fitted on the main shaft of this unit is used to stop the turbine whilst gear changes are effected.

The driver's controls can be seen in the photograph we reproduce in Fig. 4 of the locomotive cab. The main control handle operates a pressure reducing valve in a compressed air circuit. This valve varies the pressure of air to the servo control mechanisms of the gasifier and the gas turbine inlet by-pass valve. Initial movement of the control handle to increase the pressure of the servo air supply starts the gasifier and runs it up to its idling speed. Further movement of the handle accelerates the speed of the gasifier to increase its output as required. When the gasifier is operating at its minimum gas delivery the by-pass valve comes into effect to increase progressively the amount of gas flow to the turbine as it closes the outlet to atmosphere. When the by-pass valve is completely closed the gasifier servo control automatically comes into effect to adjust the fuel injection setting. As soon as the turbine torque is sufficient the locomotive begins to move. Automatic means are provided to reduce the supply of hot gas when the locomotive is running with the gasifier in operation and the load on the turbine drops to a third of its maximum capacity. This release of gas is effected in the by-pass by a double-acting valve which progressively reduces the amount of gas admitted to the turbine and exhaust to atmosphere. With these control arrangements the driver is able to adjust the power unit smoothly and easily to variable loads whilst the locomotive is running.

Two handles in the cab are used to control the transmission mechanism and, whilst gear changes are effected, the brake on the transmission unit is actuated by an interlocking mechanism. Other interlocking devices are fitted to prevent accidental damage to the transmission equipment. In the event of the locomotive getting out of control on a down gradient, automatic mechanism comes into effect to apply the brakes and close the gas inlet valve to the turbine. Operation of the gasifier is automatically stopped if the cooling water or cooling oil pressure drops below a predetermined level, or if the supply of lubricating oil to the turbine falls off.

A 90 h.p. six-cylinder oil engine drives the

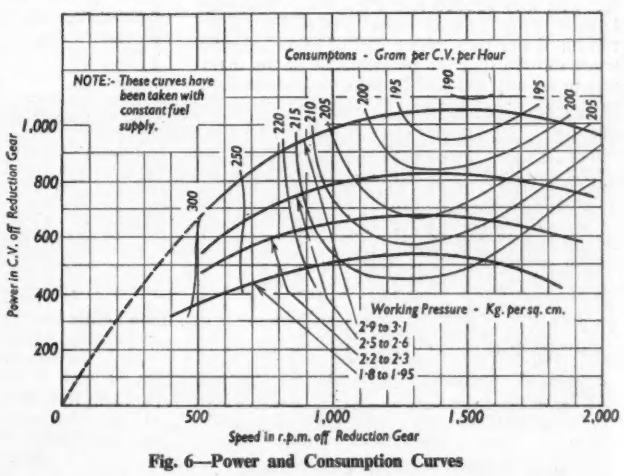


Fig. 6—Power and Consumption Curves

auxiliary equipment of the locomotive. The auxiliaries include a radiator fan, a compressor for supplying air to the braking system and servo controls, a second compressor for loading the compressed air cylinders used for starting the gasifier, an electric generator, and the water and oil circulating pumps.

The first of three series of tests was carried out with the complete power unit on the test

bench. These bench tests were made because although the free-piston gasifier's characteristics —gas power output and fuel consumption related to this output—were known, as well as to a certain degree its endurance powers, the characteristics of the gas turbine, which had been specifically designed and constructed for the locomotive, were unknown. It was decided that the characteristics of this turbine could only be usefully measured if it was fed by the gas supplied by the gasifier itself. It was also desired to examine particular operational features such as the power plant behaviour during sharp output variations, the torque value at zero turbine speed and the effect of the atmospheric conditions upon the measured characteristics.

The erection of the power plant on a test bench, as shown in Fig. 5, in addition to facili-

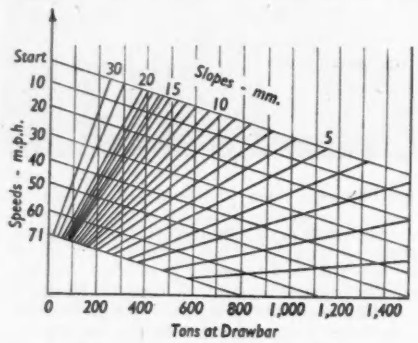


Fig. 7—Drawbar Performance at 71km/hr

tating the adjustment of the auxiliaries, the controls and the governors, enabled the efficiency of its various component parts to be studied individually.

The first tests were made with the gasifier running on gas oil and the graph reproduced in Fig. 6 shows the power outputs and fuel consumptions corresponding to different values of the speed and load. It should be noted that curves on this graph relate to four settings only of the injection pump. The fairly flat shape of the output curves showed that the plant was very suitable for traction work and the design of the turbine rotor was effective for the variable speed operation required. Unlike the results obtained with conventional gas turbines, the characteristic fuel curves that are shown in the diagram reveal a rather small variation of the consumption at partial loads—for instance, at half load, consumption is greater by only 11 per cent than at full load. It is pointed out that these fuel consumptions might appear comparatively higher than those of a diesel engine, but due regard must be paid to the fact that they applied to a plant which had only been working for a few hours and had not been run in. Later tests with a fuel of lower calorific value showed that the performance of the plant was in no way changed by using a different fuel,

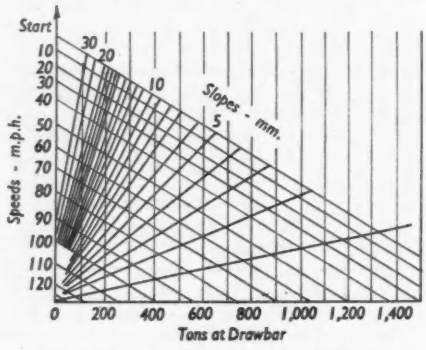


Fig. 8—Drawbar Performance at 125km/hr

the only difference was that the fuel consumption rose in proportion to its lower calorific value.

These bench tests were concluded with an endurance trial of seventy-two hours' running of the power plant at full load and varying speeds of the gas turbine. Throughout this period a fuel injection control setting corresponding to a gas power output of 1200 c.v. was maintained, the speed being increased by 100 r.p.m. every hour to cover the whole range from 5000 to 12,000 r.p.m. During this test no mechanical difficulties were experienced and the inspection which followed revealed that no undue wear had taken place.

Following the bench tests, the locomotive underwent trials on the French Railways. In the first series of trials, acceleration tests were made on the level and on gradients and hauling a dynamometer car with various loadings. It was found that in addition to exceeding slightly the expected performance, the locomotive was

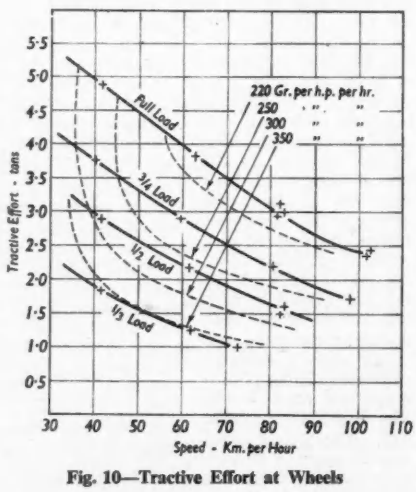


Fig. 10—Tractive Effort at Wheels

quite stable on the track and no difficulty was experienced in attaining the designed maximum speeds. In the two graphs we reproduce in Figs. 7 and 8 the drawbar performances at 71km and 125km per hour are shown.

To complete these trials the locomotive underwent tests hauling a 236-ton train similar to one in normal working on the Paris-Nord-Cambrai line over a distance of 250 miles. The fuel consumption for the round trip was 1290 litres of fuel oil for the gasifier and 108 litres of gas oil for the auxiliary diesel engine.

A further series of trials were then carried out at the bench at the Vitry testing station. Owing to the fact that the axle arrangement was different from that of a normal steam locomotive, adjustments had to be made to the results obtained upon measuring the tractive effort at the wheels. On the basis of these adjustments, the graph shown in Fig. 10 of the tractive effort at different speeds and to four loadings was prepared. In other tests which are to be made, there are to be determined the starting tractive effort and tractive efforts at very low speeds in order to ascertain the capabilities of the locomotive over its full range.

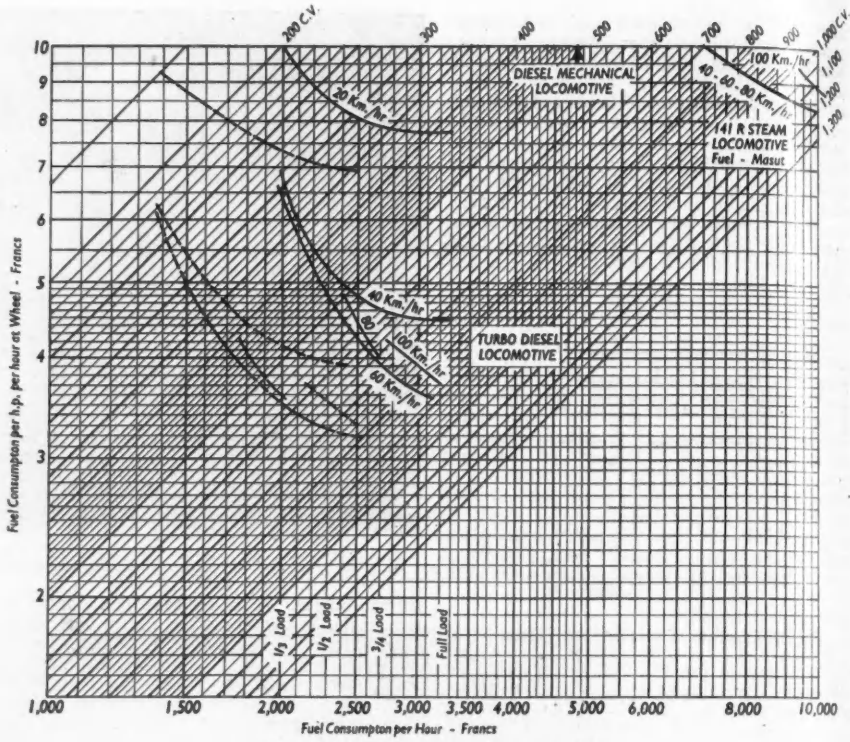


Fig. 9—Fuel Consumption Evaluated in Francs

On the graph in Fig. 10 the equivalent consumption curves of the gasifier are imposed and from them it will be seen that at some points the consumption is under 220 grammes per ch.h. at the wheel. A graph prepared by the builders of the locomotive and reproduced in Fig. 9 is of interest, for it shows, converted into log-log curves, the fuel hourly and specific consumptions evaluated in francs instead of in weight for taking into account the gas-oil consumption of the auxiliary diesel engine and the difference of price between the two fuels, the gas-oil being rated at 47Fr/kg, the light fuel oil at 13·69Fr/kg, and the heavy fuel oil at 11·39Fr/kg. It is pointed out that above the half-load for speeds over 40km per hour, i.e. in the prevailing service range, the consumptions vary from 3·5 Fr/c.v.h to 5Fr/c.v.h.

The dotted curves show respective figures when the power needed by the auxiliaries is transmitted from the main power plant, as is contemplated in future designs. This gain would be pronounced at very small loads, where the consumption of the auxiliary engine is at its maximum.

For purposes of comparison, there are shown on the same diagram the fuel consumptions of a steam locomotive burning heavy fuel oil and the optimum curves of a diesel locomotive fitted with a mechanical drive on the basis of the same fuel prices.

RESEARCH LABORATORIES AT PARTINGTON.—To investigate new uses of existing products and the possibilities of devising new processes for the production of additional compounds, Petrochemicals, Ltd., has recently completed a new laboratory at its Partington, Cheshire, works. This was opened by Sir Robert Robinson, O.M., F.R.S., and forms part of the company's plan to establish its own chemical research organisation for work on chemicals from petroleum.

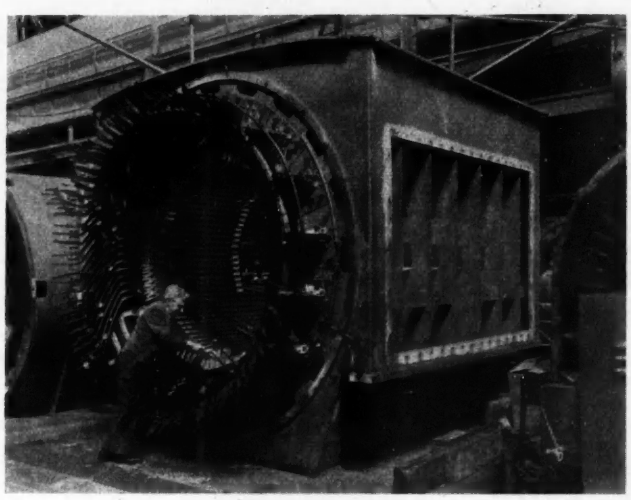
A PALLET STORAGE SYSTEM.—A film produced by the material handling division of Fisher and Ludlow, Ltd., describes the methods used at that company's Castle Bromwich works for the handling and storage of large numbers of box pallets. The system illustrated was developed in order to conserve floor space and the necessity to provide a means of accurately and quickly locating components stored in thousands of pallets—some 75,000 different components are stored.

A 40MVA Synchronous Condenser for Australia

The synchronous condenser described here is destined for the Malvern terminal station, near Melbourne, of the State Electricity Supply Commission of Victoria. Its main function will be to regulate the voltage on the 22kV distribution system, but it may also be used for charging the main 220kV transmission line. The condenser, which is the largest machine of its kind manufactured in this country, is designed so that it can be man-handled for erection or maintenance without the use of a crane larger than 3 tons capacity.

IN countries like Australia, where power is transmitted over long distances from hydro-electric stations to the main load centres, synchronous condensers are widely used for line voltage regulation with improved power factor, and for increasing the stability limits of the system. Such machines are usually installed near the load centre where they provide the required reactive kilovolt-amperes to compensate for the lagging power factor of the load when the system is fully loaded and the leading power factor of the line when the system is lightly loaded.

An interesting machine of this class is being built for the State Electricity Supply Commission of Victoria by the Metropolitan - Vickers Electrical Company, Ltd., and last week we were given the opportunity of seeing the machine on test at the maker's works, as illustrated below. This synchronous condenser is rated at 40MVA at zero leading power factor, in the over-excited condition and 25MVA at zero leading power factor in the under-excited condition. It has closed - circuit ventilation with water-cooled air. The set will be connected directly to the 22kV busbars at the Malvern terminal switching station near Melbourne, where its primary function will be to regulate the voltage of the 22kV system. It will also be available, if required, for charging the 220kV transmission line which connects the terminal station to the generating station.



Partly Wound Stator of Synchronous Condenser

There are a number of interesting aspects of the design of this machine. Despite the fact that the rotor weighs 61 tons and the stator 54 tons, the machine is arranged so that it can be handled for erection and maintenance without the use of a heavy crane. To achieve this end the set was designed to be installed on a raised concrete plinth about 30in above floor level and the air coolers were mounted on the sides of the stator frame, as illustrated herewith. With this arrangement it will be possible to remove the stator and rotor on rollers with the help of jacks and a 3-ton portable crane for handling the smaller details, as described below. By adopting this handling technique substantial economies were made in building costs : first, by dispensing with the need for a heavy crane, and, secondly, by eliminating the conventional basement and thus reducing the excavation to that required for the lubricating oil tanks.

Starting and Phasing Out

For operation as a motor generator set to charge the incoming transmission line, the condenser is driven by a synchronous induction motor fed from the 2·2kV busbars in the sub-station. The induction motor rating, based on these operating conditions with the set generating 25,000kVA at zero leading power factor, is 1160 h.p. (916kVA at 1·0 power factor), and the starting motor carries its own overhung exciter rated at 54V, 660A. It is economical to use the same synchronous induction motor for starting the condenser, thereby avoiding the extra cost of separate starting equipment which would involve voltage-reducing apparatus.

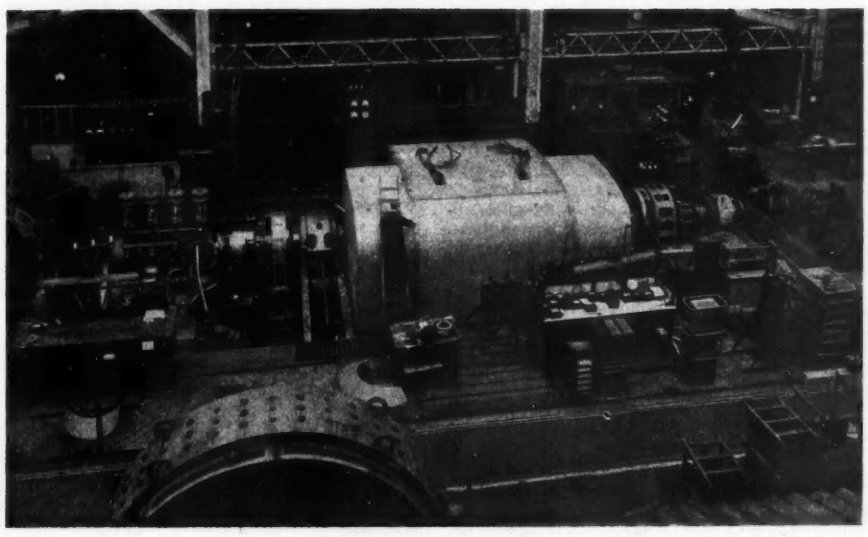
To start the condenser the synchronous induction motor is connected to the 2·2kV busbars and the set is started up on an external resistance by normal induction motor methods. A fixed value of excitation is then applied to the motor field, and the machine pulls into step. The condenser is then excited to produce the required system voltage and the phase relationship between the supply voltage to the motor and the generated voltage of the condenser is adjusted by varying the relative excitation of the three phases of the starter motor rotor winding. This procedure for phasing out is based on a method developed by the manufacturer for rotating the rotor field instead of rocking the stator. Electrical displacement of the poles of the driving motor rotor is achieved by altering the distribution of field current in the rotor windings as follows. The rotor winding is a normal three-phase star connected winding, and for synchronous operation two of the phases are connected in parallel and the d.c. supply is connected to the common terminal and the terminal of the other phase. To change the current distribution in the windings, a phasing resistance is connected between the parallel windings, and the distribution of field current in the windings is altered by moving the tapping point along the resistance. The value of phasing resistance is so chosen that a variation in the phase angle of ±18 deg. can be obtained. Larger changes of angle which may be necessary are obtained either by reversing the condenser excitation, by changing over the phasing resistance to another pair of phases, or by changing the position of the coupling between the motor and the condenser. Thus, any change of phase angle between 0 deg. and 360 deg. can be obtained. Having adjusted the excitation to produce the correct voltage and phase angle, the condenser is connected to the 22kV system in the normal way. The condenser excitation can then be adjusted, either manually or by automatic voltage regulator to operate the set at the required load.

Excitation is provided by a main exciter rated at 200V, 575A (115kW) continuously, with a peak output of 370V, 1050A for super-excitation ; a differential field winding provides a voltage variation of 10 : 1 to cover the range of output of the condenser. The field circuits of the main exciter are supplied, under the control of a Metropolitan-Vickers "VS" automatic regulator, from an auxiliary exciter rated at 230V, 28A (6·5kW) continuously, with a peak output of 36A at substantially constant voltage. Both exciters are carried overhung as an extension of the main shaft at the slipring end—that is, opposite to the driving motor end.

Dismantling Procedure

To simplify maintenance procedure, the joints between adjacent covers of the stator are so arranged that any one section can be quickly removed without disturbing the others. Removal of either side cover gives access to one of the air coolers and to its cooling water inlet and outlet valves. Removal of one-half of either end cover exposes the inner winding guard carrying the fan shrouding ring and the inner shaft cover. The winding guard is made in four parts ; a lower quarter can be displaced sideways and lifted over the plinth, without disturbing the upper quarter.

Whereas the main bearing at the driving motor end stands on the closed end of the concrete plinth, that at the exciter end is carried by a deep steel beam spanning the open end of the plinth. This beam is for use in dismantling, and three stages in the operation are illustrated,

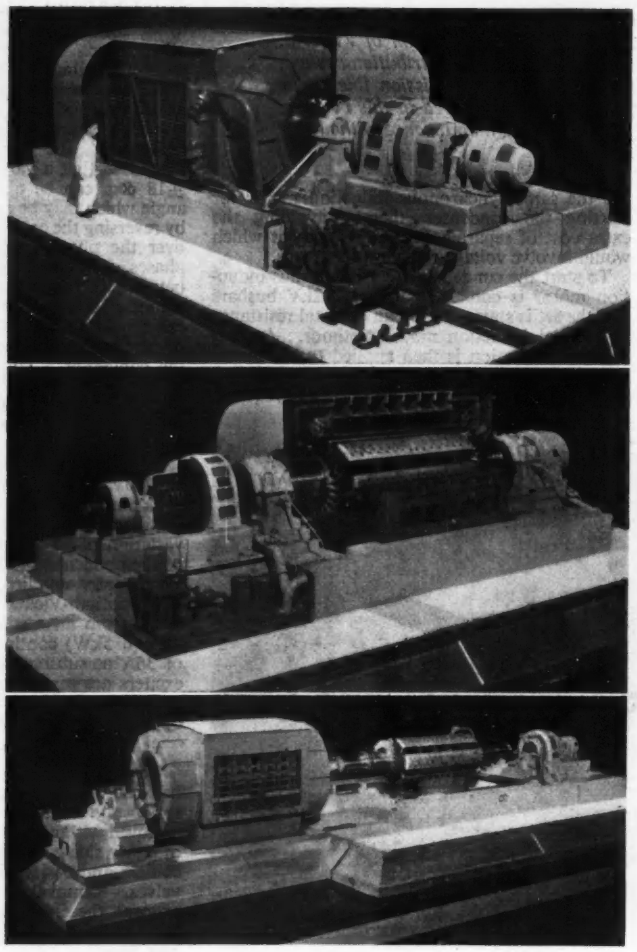


Synchronous Condenser on Test

herewith, by photographs of a model, the first step being to remove the main and auxiliary exciters. An extension shaft is then bolted to the main shaft in their place. All enclosing covers (and the fan shrouding rings) are next removed, and the outer end of the extension shaft is lifted on two 20-ton jacks, operated by a portable oil pump, sufficiently to permit removal of the main bearing bush. The beam, with the pedestal which it supports, can then be withdrawn (on skid plates) far enough to allow the shaft to rest on packing blocks under the main journal. The jacks and the beam can then be taken away.

The air coolers are next removed, and four jacks are inserted in one side of the stator frame, which is lifted slightly, so that roller trollies can be placed on a rail under that side of the stator. The operation is repeated at the opposite side. Two jacks are now transferred to the outer end of the extension shaft, the packing blocks are removed, and the stator is withdrawn on the rollers far enough to expose most of the rotor body, further roller trollies being inserted as required.

The driving motor is then uncoupled from the main shaft, and the complete motor assembly on its baseplate is pulled back sufficiently to allow a lifting bracket to be bolted to the main shaft. Lifting this end slightly on two jacks allows the bearing bush to be removed, and a wheeled truck and cradle to be assembled under the centre of the rotor. All jacks are then lowered and removed, allowing first the stator and then the rotor to be withdrawn.



Scale Model Showing Stages in Dismantling of Synchronous Condenser

Constructional Details

The stator, which is shown partly wound in one of our illustrations, consists of a welded steel frame. Bars are welded to the ribs of the frame to support the core which is built of silicon alloy segmental stampings of the "straight back" form, with non-magnetic tooth supports and vent spacers.

The winding is of interest because of the high voltage. It is a two-layer winding with all coils identical, having formed involute ends, clamped by brass bolts and plates to angle brackets of compressed hardwood. The individual strips of the laminated conductor, and the complete coil, are insulated throughout with mica-silk tape, vacuum dried and impregnated in bitumen. After impregnation a stripping tape is removed and the bars are hot pressed to the required dimensions for placing in the slots. The coils are jointed by butt welding at both ends to facilitate insertion or removal without distortion.

As shown in our illustration of the partly wound stator, the coil ends are supported on segmental rings carried by "Permali" brackets bolted to the core end-plates. Packing blocks are taped between adjacent coil sides to prevent lateral distortion of the winding on short circuit.

The rotor body and poles take the form of a steel casting with a hole bored along the axis of the body to permit inspection of the casting. Stub shafts are bolted to the rotor body and the pole tips are secured by high-tensile bolts. The field winding is of rectangular "fabricated" coils, built up from side and end bars, with a dovetailed brazed joint at each corner. Every fifth bar is wider than the others, forming a projecting cooling fin. Adjacent bars are separated by asbestos paper, bonded with a thermal hardening varnish and solidified under heavy pressure. The coil is insulated from the pole by hard, flat sheets of Bakelite-glass board, with thick collars of Bakelite-fabric board at top and bottom. Dovetailed Y-clamps support the coil against lateral deformation under the influence of centrifugal forces, which, in a rotor of this size, reach 1000*g* at 15 per cent over-speed.

The axial-flow fans at either end of the rotor are bladed with cast aluminium alloy.

The lubricating oil tank is partly below floor level at the starting motor end of the set. The tank contains two motor-driven, low-pressure oil pumps, which provide oil circulation to the two main bearings. Either pump may be in service, with the other as standby. Automatic starting of the standby pump is provided, in case of failure of oil circulation. The standby pump unit complete can be lifted from the tank while the machine is in service. The oil inlet to each pump is fitted with duplicate strainers, either of which can be lifted out for cleaning at any time.

Oil is delivered from the pumps to a bank of four oil coolers in parallel. Three units are sufficient for continuous operation. The combined oil delivery from the coolers is taken to the two main bearing pedestals through an oil flow relay (visual and contact making). The outlet oil from the exciter end pedestal returns through a pipe embedded in the concrete plinth to join the outlet oil from the motor end pedestal in a common entry at the side of the oil tank.

The oil tank also contains a motor-driven, double-outlet, high-pressure oil pump for injecting oil under the two main journals to relieve the initial friction at starting.

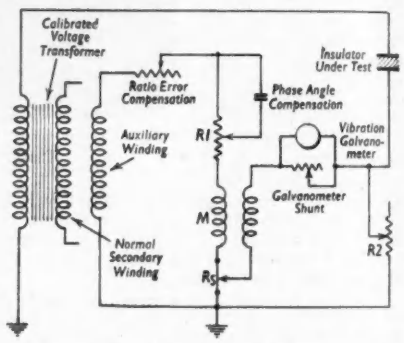
On-Load Power-Factor Testing of Bushings

The following description of a method of testing the power factor of insulator bushings on load is abstracted from a paper, "The Testing and Specification of Bushings in Relation to Service Conditions," by Mr. H. Barker and Mr. H. Davies. This paper was presented and discussed at a meeting of the Supply Section of the Institution of Electrical Engineers in London on Wednesday, February 25.

Power-Factor Testing On Load

Experience with modern insulators indicates that regular power-factor testing on site is, in most cases, not necessary. In the case of very important busbar insulation, however, it may be thought necessary to keep a check on the condition of the insulation and provision for testing may be required. It is only at very infrequent intervals and at most inconvenient hours that the system can be made dead for testing, and certain schemes have been considered for testing on load. One such scheme, which has been used successfully, is shown in the accompanying diagram.

A variable resistor $R2$ is connected in series with the insulator under test. The voltage drop across this resistor is balanced against the sum of the voltages developed across the secondary of the mutual inductor M and part of the slide-wire resistor R_s. The primary of M is energised from an auxiliary winding on a calibrated voltage transformer through a current-limiting resistor $R1$. The bridge is balanced by successive manipulations of the resistances R_s and R_s, balance being indicated by the vibration galvanometer. The power factor of the insulator under test is given by $r/\omega M$, where r is the portion of R_s in series with the secondary side of the mutual inductor and M is the mutual inductance. If the mutual inductance is fixed at 31·83mH, the power factor of the insulator under test is given by $r/10$ and can be read direct from the slider scale, the resistor R_s being calibrated in power factor. The capacitance of the insulator is given



Apparatus for Power Factor Testing on Load

by $K \times R_s$=constant. Ratio and phase-angle compensation, as shown in the diagram, are necessary to correct the errors introduced by the voltage transformer and mutual inductor, and these should have been previously measured and recorded for various working burdens.

The method can only be used on equipment in which the low-voltage ends of the bushings can be detached from earth (e.g. tapped condenser bushings). All the leads from the bushings are screened and taken to a convenient point, where the screened leads from the test set can be connected, usually by a plug and jack arrangement.

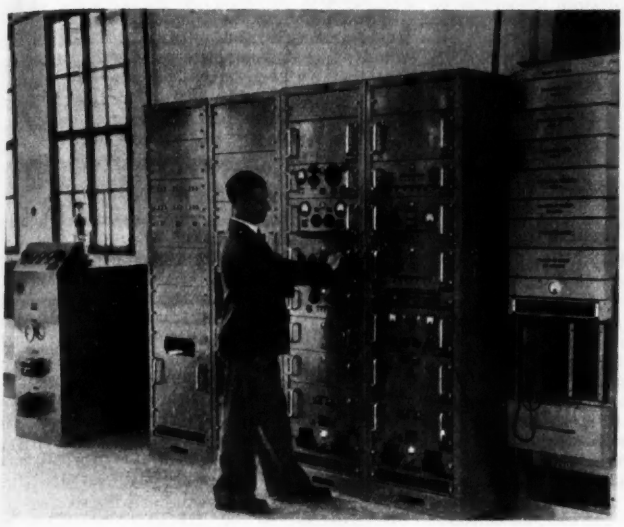
With on-load testing, the relationship between power factor and voltage cannot be measured, but since the value is obtained at the working voltage to earth of the system, any deterioration should be indicated long before the condition of the insulation becomes dangerous.

Air Transport, January, 1953.—Air transport movements at United Kingdom aerodromes in January, 1953, numbered 10,400, approximately 4 per cent less than in January, 1952. The total of passengers handled was 144,700, over 9 per cent more than in January, 1952. Freight on and off-loaded amounted to 2870 short tons, a decrease of 7·5 per cent. Post Office mail decreased slightly to 1050 tons.

Radio-Telephone Link between Turkey and the West

On February 16th, a new radio-telephone link was brought into service between Turkey, Western Europe and the U.S.A., and a similar service between Turkey and Great Britain was expected to be in operation last week. Besides providing for this radio-telephone service the newly built stations will augment the long-distance radio-telegraph facilities of the Turkish Republic, by extending the existing system from Istanbul and by introducing direct circuits from Ankara. For the first time Turkey now has facilities for a teleprinter service.

Equipment for the new radio-telephone service between Turkey, Western Europe and the U.S.A. was designed, supplied and installed by Standard Telephones and Cables, Ltd., in collaboration with the Turkish Posts and Telegraphs Administration. It embodies the radio-telephony system used by the British Post Office. The installation allows one or two channels to be used simultaneously, but it is so designed that, with minor additions to the equipment, the number of channels can be substantially increased to cope with growth of traffic. Telephone conversations over the new link are made private by a system of "scrambling" similar to that used on the world's major radio links, including those between Europe and the U.S.A., and is, of course, capable of being worked with them.



Transmitter Drive Units at Ankara

To house the equipment for this service a number of radio stations have been built by the Turkish Posts and Telegraphs Administration on selected sites, connected by armoured underground cables to the central office in Ankara, where the operation of the system is controlled.

In Ankara there is a new radio transmitter station which accommodates two 40kW peak transmitters, one for telephony and one for telegraphy.

The telephone transmitter uses single-sideband transmission, whereby one equipment can carry several telephone conversations simultaneously without mutual interference and gives a much higher signal-to-noise ratio at the receiving end for the same transmitted power than is obtainable with the older double-sideband transmission.

The single-sideband circuits are contained in a small unit which operates on a fixed frequency. The output from this unit is converted in the transmitter proper to the frequency required for the actual transmission—which is different for day or night—and is increased in power to either 4kW or 40kW, according to whether propagation conditions are good or bad. The transmitter drive units are illustrated herewith.

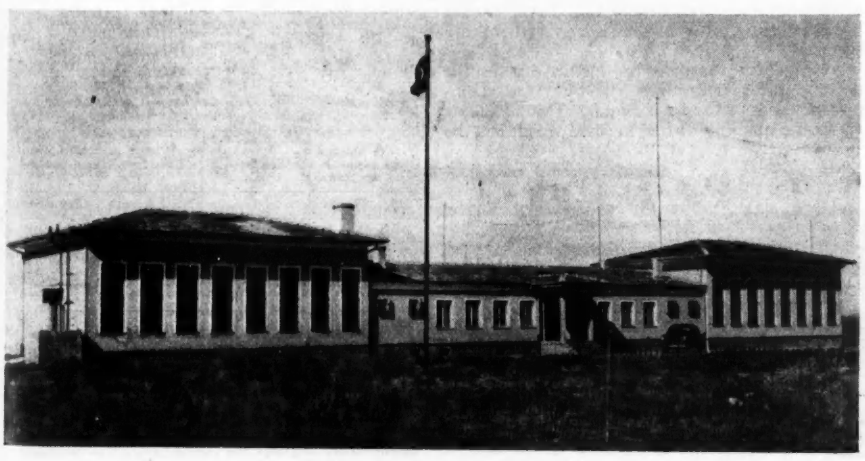
The telegraph transmitter at Ankara is designed to be interchangeable with the telephone transmitter and, therefore, can be used as a standby. For telegraphic working the small single-sideband unit is replaced by a telegraph unit working on the frequency-shift principle, whereby a signal is sent out during both the "active" and "idle" periods, but on a slightly different frequency, so that one can be distinguished from the other at the distant receiver. Transmission of a signal during the "idle" period helps to suppress noise and interference, and thus allows teleprinters to be used, if required, instead of morse apparatus. Rhombic aerials increase the effective power of the transmitters by as much as fifty times, and a number of these aerials are installed to serve different places. Omni-directional aerials are also provided.

At the Ankara receiving station, illustrated herewith, there is a triple-diversity single-sideband receiver built to the same performance requirements as those of the British Post Office. The installation consists, in effect, of three receivers in one unit, all three working on the same frequency, but with separate aerials spaced away from each other, giving a choice of aerials which makes the service less susceptible to fading.

The Ankara station also houses a number of telegraph receivers using the diversity principle and, to economise in cost (since high-efficiency directional aerials are used), special arrangements have been made to permit several receivers to work simultaneously from one aerial system.

Multi-pair cables connect the radio stations with the central office in Ankara, which accommodates the apparatus for connection to the public network and the scrambler systems for ensuring that conversations are private. This terminal equipment incorporates special voice-operated electronic circuits for switching the transmission path to avoid the "echo" effects which can otherwise occur on short-wave radio-telephone systems. The apparatus also includes amplifiers which automatically adjust themselves to cover a wide range of different levels of incoming speech from the subscribers. Power for the transmitters and receivers is fed to the stations from Ankara along a new armoured underground cable, and there are standby Ruston and Hornsby diesel-electric plants at both stations.

Apart from the new stations at Ankara, the radio system now going into service provides an additional high-power telegraph transmitter at Istanbul, together with a number of associated receivers.



Receiving Station Building at Ankara

A Conductive Ceramic for Microwave Applications

In waveguides for microwave work, dummy loads are required to absorb the radiation without reflecting more than a small fraction of it. Hitherto these dummy loads have consisted of conductive particles embedded in an insulating matrix—for example, carbon in asbestos, or such materials as wood which are poor insulators—but these materials suffer from the disadvantage that, when high local temperatures occur, because of the absorption of high powers, their electrical properties alter and, in some cases, physical distortion occurs. Recently, however, a conductive ceramic "Caslode" has been developed by the Plessey Company, Ltd., Ilford, Essex. It is a white, homogeneous material, capable of absorbing power at centimetre and millimetre wavelengths, and can thus be used effectively for high-power dummy loads and attenuator pads in waveguide applications. "Caslode" is a true semi-conductor, and does not contain dispersed conductive particles. At 3·2cm wavelength its dielectric constant is about 20, and the loss angle 10 deg. to 20 deg.

During manufacture the material is fired at a high temperature to form a homogeneous structure which is stable under extreme conditions of temperature and humidity. Its thermal shock properties are good and its coefficient of linear expansion is 6×10^{-6} per deg. Cent. Mechanically, "Caslode" is similar to porcelain, but it can be ground and shaped rather more readily. The raw materials are formed into the required shape before firing and precise dimensions and a good surface finish are subsequently obtained by wet grinding.

High-power dummy loads of this material have been developed to meet the demand for a matched waveguide termination capable of absorbing high powers without the necessity for water cooling. Wedge-shaped components have been designed to operate in the common sizes of waveguides. Recent measurements have indicated that units originally developed to give a match of about 0·95 and to dissipate about 100W mean power at 3cm wavelength can absorb 250W mean power without any appreciable change in matching properties. Where a load must occupy the minimum possible space, "Caslode" can be formed into short wedges (e.g. 5cm long for X-band waveguides), which give a match better than 0·85 and an attenuation of the order of 30 db.

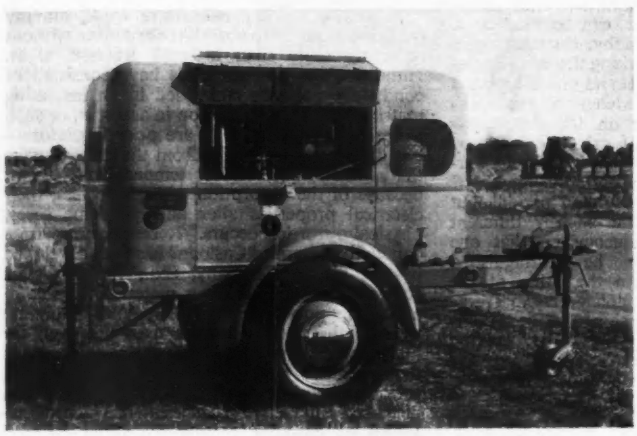
The "Caslode" attenuator pad is still in the experimental stage, but units of the slot insertion type have been produced, having an attenuation figure of 28 db. with a match of 0·95. These units have been tested up to a mean level of 15W dissipation, and could probably absorb a higher level of power.

Wire for Prestressed Concrete.—We have received from Richard Johnson and Nephew, Ltd., Forge Lane, Manchester, 11, a brochure giving descriptive information and specifications of wire for use in prestressed concrete, as manufactured by that firm. Copies are available from the firm on request.

Free-Piston Portable Air Compressor

AN illustration on this page shows one of the portable air compressor sets which are now being made in this country by Alan Muntz and Co., Ltd., Hanworth Air Park, Feltham, Middlesex, and which incorporate a free-piston compressor unit designed and developed by the makers, using Pescara principles. These sets have a free air discharge of 105 cubic feet per minute, and a maximum operating pressure of 100 lb per square inch with a fuel consumption of about 7 pints an hour of diesel oil.

The principle upon which the Pescara type free-piston compressor operates is now generally known, but, as a matter of interest, the arrangement of the compact unit fitted to this set is shown in the drawing we reproduce below. It consists essentially of a central, two-stroke, diesel cylinder unit with opposed pistons *A* and *B*. The piston *A* is connected through its rod with a cushion piston *C* and the piston *B* with a compressor piston *D*. The two piston-rods are coupled through links at each side to central rocking levers, one of which is shown at *E*. These rocking levers are mounted on rocking shafts carried on bearings on each side of the engine casing. Through the system of links, the two sets of pistons act in unison and the length of their strokes is maintained equal.



Portable Air Compressor

In the operating cycle, on the expansion stroke, as the compressor piston on the right-hand side is driven outwards, compressed air is forced out through plate valves in the cylinder head and the delivery branch *F* to the air receiver. During this movement air is drawn into the back of the cylinder through the scavenge suction valves *G*, and this air is compressed on the return stroke for engine scavenging purposes. Whilst air is being compressed and delivered at one end of the unit, the cushion piston at the other end compresses air in the head of its cylinder.

At the end of the working stroke the right-hand diesel piston uncovers scavenge air ports *H*, and compressed air from a small built-in reservoir below passes into the combustion chamber. This air sweeps through the cylinder to discharge the products of combustion through ports uncovered by the piston at the other end of the cylinder into the exhaust branch *J*.

At the end of the firing stroke the air compressed in the cushion cylinder provides the energy to return the pistons and compress the air in the engine cylinder for the next cycle. During this return movement air compressed at the back of the compression piston passes through the valve *K* into the scavenge air reservoir, and a further supply of air from the atmosphere is drawn into the head of the cylinder through an oil-washed filter. Towards the end of the engine compression stroke fuel is introduced by two injectors into the centre of the diesel cylinder, and, on firing, the next working cycle begins.

The cushion cylinder has a ring of ports round its rear end and through these ports make-up air is drawn at the end of the compression cycle to compensate for any losses. At the head of this cylinder is a small air chamber with a port opening into the cylinder proper. This port is opened and closed by a handwheel-controlled valve. When a high cushion compression ratio is required to give a higher diesel compression when starting the unit, the port to the chamber is closed. Once the unit is running the port is opened to increase the volume of cushioning air. To assist in obtaining the requisite return energy when starting the unit, the delivery valves of the compression cylinder are kept closed by spring-loaded blocking pistons which automatically lift when the working pressure has been reached.

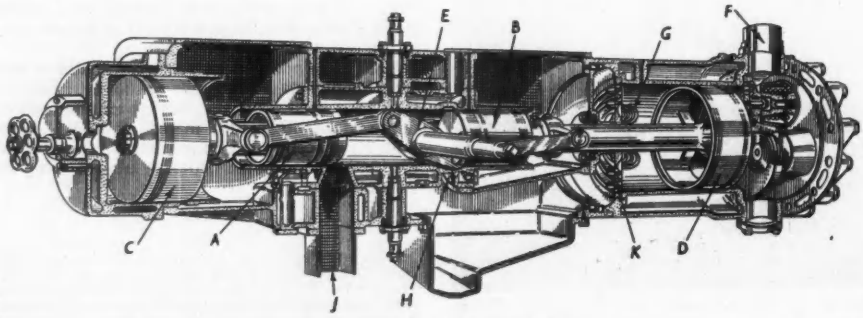
For starting the unit, a specially designed spring operated starter gear is fitted on one of the rocker shafts projecting through the side of the engine case. A crank handle on the starter operates through a chain reduction gear, and as the handle is turned a pawl engages a slot in the rocking shaft and starter springs are compressed. After about twenty-eight turns of the handle, the fully compressed starter springs are automatically released and through the pawl turn the rocking shaft to throw the diesel pistons towards the centre of the cylinder. The starter pawl is automatically disengaged from the rocking shaft as the pistons are freed for the firing stroke which follows.

The rocking shaft connected to the starter also carries a double cam which operates the fuel injection pump and drives the main pump supplying lubricating oil from the sump to all bearing surfaces.

A regulator sensitive to fluctuations in the delivery pressure controls the output of compressed air to a fixed maximum. This regulator varies the quantity of fuel injected which has the effect of varying the length of the working stroke. The exhaust gases from the engine are used to drive a small turbine which runs at about 1000 r.p.m. when the compressor is working at full output. This turbine drives the radiator cooling fan and a pump which circulates cooling water round the jackets of the compression and cushioning cylinders of the unit. It also drives through a worm gear a metering pump supplying lubricating oil to the compressor cylinder.

The air compressor unit of the portable set illustrated has a diesel cylinder bore of 4·25in, a compressor cylinder bore of 9in, and a cushion cylinder bore of 8·25in. As already mentioned, the length of the working stroke is set by the amount of fuel injected, and in this case at no load the stroke is 5·52in, and at full load 5·98in, the respective speeds being 1130 and 1100 cycles per minute.

The compressor unit is mounted on a rigid frame trailer carried on two pneumatic-tyred wheels, and the complete set weighs just over 2900 lb.

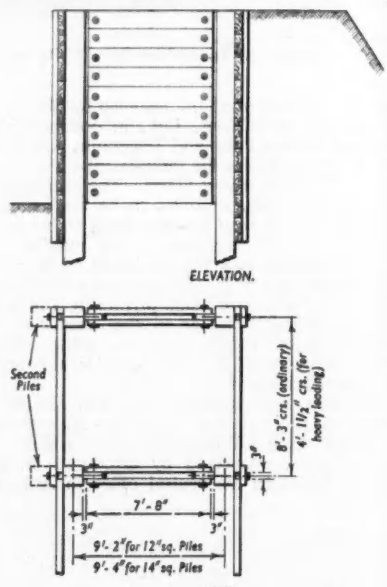


Arrangement of Compressor Unit

Precast Prestressed Concrete Units for a Sea Wall

WE have received from Dowsett Holdings, Ltd., Tallington, Stamford, Lincs, details of a system of precast prestressed concrete units which may be used to form groynes or built up to make a hollow sea wall. The system has been developed by the subsidiary company, Dow-Mac (Products), Ltd., and consists of piles and walings which may be bolted together to form the structure required. The diagram herewith shows the arrangement suggested to form a hollow sea wall from these units, one cell of the wall being illustrated in plan.

The piles are either 12in or 14in square, with bearing capacities of 80 and 110 tons respectively.



Pile Requirements at 4ft. 1½in Centres :—12in Square for 3 to 8 Walings ; 14in Square for 9 Walings

No. of walings high exposed on sea face		Sea face		Land face		Min. width of backing	
No.	Height	No.	Length	No.	Length	Clay	Sand
	Ft in		Ft		Ft	Ft	Ft
3	3 6	1	15	1	15	—	—
4	4 8	1	15	1	15	—	10
5	5 10	1	20	1	20	2	10
6	7 0	1	20	1	20	4	10
7	8 2	2	25	1	25	7	10
8	9 4	2	30	1	30	9	10
9	10 6	2	30	1	30	11	10

Note.—The schedule is based on a loading of 1 ton per square foot on the seaward face. For ½ ton per square foot the piles may be spaced at 8ft 3in centres.

Suggested Assembly of Precast Concrete Units

and are manufactured in multiple lengths of 5 ft up to a maximum of 80 ft. Walings with dimensions of 2ft 4½in by 4½in by 15ft long, 14in by 4in by 8ft long, or 12in by 3in by 7ft 8in long, may be employed. The 14in by 4in by 8ft long walings are designed to withstand a load of 1 ton per square foot on an unsupported span of 4ft between piles, and the suggested design for the wall is based upon this loading, giving a panel loading of 4 tons per foot in height. With this loading, the necessary pile lengths are given in the legend for a pile spacing of 4ft 1½in centres. It is assumed that the box core when filled with earth or sand will have an initial resistance to overturning calculated from the full weight of earth and concrete in relation to the exposed maximum height of either face.

It is pointed out by the makers of the units that the earth filling will increase the waling resistance over its design strength, and that the toe wall or raised pitching to be constructed on the front can be taken into account when calculating final overturning, as can the earth banking to the rear wall of the box. In the event of wall height exceeding the limits set out, the internal bulkhead struts may be increased in length and section to give a core wall of greater width. Under severe conditions the whole of the interior of the box may be filled with weak concrete to make a solid core and, if necessary, further bearing piles may be driven along the centre of the core. If a cut-off wall is desired, a line of sheet piles can be driven either along the centre line of the core in place of additional bearing piles, or in front of or behind the box core.

Corrosion Resistance of Aluminium to Coal Gas

To ascertain the suitability of aluminium alloys as a structural material in a gasworks, the South Eastern Gas Board decided to install an aluminium roof over the dry purification plant at the Sevenoaks, Kent, Gasworks. This particular part of the plant was selected for the test because the severity of the conditions of exposure was known and the roof was built in February, 1948, by the Aluminium Construction Company, Ltd., using material supplied by the Northern Aluminium Company, Ltd. No paint or any other form of protection was applied to the structure, which was constructed of aluminium alloy sections to British Standard Specification H.E.10, and corrugated sheet to Specification N.S.3.

Although the original brightness has disappeared, the condition of the roof, after nearly five years, shows very little evidence of deterioration, only slight surface roughening and pitting being revealed by a superficial examination. However, to verify the apparent soundness of the roof, Aluminium Laboratories, Ltd., in January, 1952, examined a structural member and a roofing sheet and found evidence of only very slight corrosion. A metallurgical examination of the sectional material indicated that the mean depth of pitting corrosion was 0·0063in with a maximum of 0·0173in. Since the thickness of the flanges and web of the member in question was ¼in and $\frac{1}{16}$in, respectively, the amount of penetration was insufficient to reduce the strength appreciably and check tests showed that the tensile properties were still in excess of the minimum specified for H.E.10 material. The maximum depth of pitting on the inner surface of the sheet specimen, which was 0·028in thick, was 0·0047in, while only slight superficial corrosion was found on the outer surface. Again, tensile tests revealed that the pitting had not caused the properties of the sheet to fall below the minimum for N.S.3 material. Based on these results the Gas Board has used aluminium alloys for the roofs of its works at Wandsworth and Guildford.

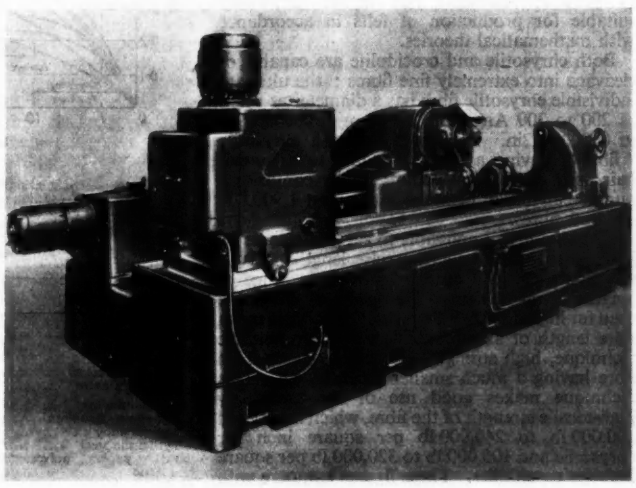
Many years of research have established that pitting is the main form of attack upon aluminium alloys exposed to aggressive atmospheres, the pits forming at the weakest points in the protective oxide film. The onset of pitting may be rapid but this rate of formation of new pits will diminish; moreover, under many conditions, a new oxide skin is formed, which prevents further attack. A graph showing the loss of strength obtained from tensile tests, taken at intervals, and plotted against a basis of time, forms an exponential curve, which indicates that, in the main, the rate of corrosion will gradually diminish until corrosion stops. For the alloys used in this instance the deterioration is very slow after three to four years, so that from the results obtained the roof can be expected to give more than twenty-five years' service.

Assuming that the life of a galvanised steel roof is twenty-five years, it is estimated that the cost of painting the structure on alternate years during that period will amount to £2040 and this added to the initial cost of £830, makes the total overall cost £2870, which can be compared with the first cost of an aluminium alloy roof, amounting to £1450.

A Horizontal Gear Shaving Machine

THE photograph we reproduce on this page shows a horizontal gear-shaving machine which has recently been completed by David Brown Machine Tools, Ltd., of Manchester. This machine is designed for shaving gear tooth profiles of large turbine pinions, where close tolerances and high quality finish are required, and it was built to the requirements of the Fairfield Engineering Company, Ltd., of Glasgow. It will shave pinions of 4in to 24in diameter and up to 100in long.

Embodied in this interesting machine, which is believed to be the first of its kind built in this country, are several points of design evolved by the makers through recent experience in developing a range of vertical axis shaving machines. The machine is of particularly rigid construction weighing some 20 tons, and is designed for shaving by the radial loading method, whereby both flanks of the gear tooth are cut simultaneously. If required, an oil-cooled brake can be fitted to the cutter spindle to allow single-side or selective shaving.



Horizontal Gear Shaving Machine

The main bed, which is a single casting, has guideways to provide location for the driving head and tailstock, and for the saddle carrying the shaving cutter head. Provision is also made for the fitting of work-steady brackets in any required position. Complex drives are eliminated by the adoption of independent driving units for both the work driving head and the cutter saddle traverse. Longitudinal hand traverse of the workhead and tailstock is effected by rotating spur pinions engaging with a rack located at the front of the bed. The work drive head, which is also designed as a self-contained unit, is fixed to the bed and is powered by a constant-speed 5 h.p. motor. This drive is taken through worm and helical gears and a series of change gears gives a choice of spindle speeds ranging from 21 to 300 r.p.m. For setting purposes the driving spindle can be run independently of all other machine motions.

The saddle feed gearbox is fitted as an independent unit at the rear of the machine bed and it provides for longitudinal traverse of the cutter. Drive to the saddle traverse screw is supplied by a 3 h.p. motor and the rates of feed available range from 0·17in to 3·3in per minute. A rapid power traverse of 20in per minute is provided. Adjustable stops control the length of traverse and a hand-operated reversing switch is used to change the relative directions of motion.

Angular adjustment of the shaving cutter head is made by means of a hand-operated worm and wheel, and a vernier scale facilitates quick and accurate setting. The final fine adjustment is obtained by reference to a dial indicator, which is in contact with a setting bar located by a slipping ring in the cutter head. A hand-operated in-feed slide engages the shaving cutter in mesh with the gear and three handwheels, incorporating graduated scales, enable adjustments to be made from any of three positions.

The electrical control gear is mounted on a panel at the rear of the machine and an isolator switch is incorporated in the panel door. The various motions of the machine are controlled by duplicated push-button stations, one of which is at the front and one at the end of the machine. A rotary changeover switch selects the direction of rotation of the driving spindle relative to the direction of feed and limit switches prevent over-running.

Automatic lubrication systems are fitted for the work driving head and saddle feed gearbox. The saddle guideways and feed screws are lubricated by a hand-operated pump and the gears in the in-feed bevel box run in an oil bath.

A self-contained motorised gear pump supplies the shaving cutter with a continuous flow of cutting lubricant, which subsequently passes through two magnetic filters and a box strainer before being allowed to recirculate.

Production of Thorium in South Africa

EXTENSIVE deposits of monazite, which are capable of being worked for thorium production when the need arises, have been found in several African Colonies, and a new ore-field has been discovered recently in the north of Cape Province which has more than doubled the previous world output. This mineral is the principal source of thorium, from which is produced the fissile element Uranium 233. This element has not as yet been required by the British atomic energy effort in more than experimental quantities, but it may well be that greatly increased demands may arise in the future. This discovery is the more important since export of the large deposits of the Beach Sands in Southern India, is now prohibited.

The South African monazite is a heavy brown mineral, pebbles of which, derived from a bed rock reef, are found lying on the surface of the Nama desert, about 50 miles north of Van Rhynsdorp. Because of its weight, the bushmen preferred monazite to other local rocks for sling stones and arrow heads. Since the deposit was found in 1950, it has been extensively diamond-drilled by the Anglo-American Corporation of South Africa, Ltd., to whom the rights to mine and concentrate the ore and to export the products have been granted by the South African Atomic Energy Board. The Corporation has announced that all production up to March, 1956, has already been sold, principally to the United States, and that, throughout this period, the output is likely to be maintained at 8000 tons annually.

New Materials and Methods for Aircraft Construction*

By H. J. POLLARD, Wh.Ex., F.R.Ae.S.†

In this abstract the author discusses some aspects of the manufacture and use of certain new materials for primary structure. These materials include "asbestos," "Durestos," glass and cellulose fibre laminates, resins and foamed resins. The metal alloys discussed are those of aluminium, magnesium and titanium.

BASIC structural design has varied considerably during the past few years and is now being profoundly influenced by the advent of high subsonic and supersonic speeds, but all construction still relates chiefly to the use of aluminium. I believe that the time has come when its use may be challenged for certain ranges of aircraft structure and that certain materials will come into use for primary structure as first did wood, then steel and then aluminium alloy. The older materials will continue to be used in the foreseeable future, particularly aluminium alloy, but the use of certain of the new materials, notably asbestos and glass-reinforced plastics, over certain ranges of size and types of aircraft, should result in more efficient and decidedly cheaper structure and other components.

Although a few odd items such as glass and asbestos ducting, and the like, find secondary application in aircraft to-day, there has been, as yet, little attempt to use such materials as asbestos and glass-based plastics in the practical design and manufacture of aircraft structure for actual flight. That the weight and cost saving possibilities of the "new" materials have not been fully realised hitherto is probably due to the fact that, for most projects, aluminium alloy has proved immediately adequate both from a technical and production standpoint.

Referring to Table I, it may seem odd that materials with such low specific properties as the asbestos and glass-based plastics have any range of efficient structural application at all. It is well known, however, that a large proportion of the weight of an aircraft structure consists of the weights of those components or elements where stability of the structure in compression is the controlling factor in the design. In such cases, over the lower ranges of structural loading, the weight of the optimum structure may vary inversely as $E^{\frac{1}{2}}$ (Young's modulus) divided by the material density, rather than inversely as the specific strength or specific stiffness. On this basis, as seen from Table I, the asbestos plastic materials are considerably superior to aluminium alloy.

Fig. 1 shows that each of the materials has a distinct range of efficient structural use and that, over the lower loading ranges, highly efficient structures on a strength-weight basis may be designed in the comparatively low strength, low stiffness plastic materials.

In addition to tensile and compression strength considerations, torsional stiffness may have an important bearing on the weight of a design, and although these materials may show to disadvantage in some cases, experience has shown that in many instances the difficulty may be overcome by a rearrangement of component geometry.

The potential structural efficiency of strong plastics may not be enough at this date to induce anyone to embark on design and employment of the methods of manufacture to be described, but there are other very attractive features—for example, final low cost and the attainment on a component of an extremely smooth exterior surface. These things taken together should be sufficient to persuade all technical and manufacturing executives in the industry to give the subject their early attention.

TABLE I—*Certain "Constants" for the Materials Considered*

	Specific gravity	Design tensile strength, lb/in²	E Young's modulus, lb/in²	Specific strength, lb/in²	Specific stiffness, lb/in²	$\sqrt[3]{E} \div$ specific gravity
Asbestos phenolic plastic : Grade 1	1·6	24,000	$2·8 \times 10^6$	15,000	$1·75 \times 10^6$	88·0
Asbestos phenolic plastic : Grade 2	1·6	15,000	$2·4 \times 10^6$	9,400	$1·50 \times 10^6$	83·7
Woven glass polyester laminate	1·7	40,000	$2·2 \times 10^6$	23,500	$1·29 \times 10^6$	76·5
Resinated paper	1·25	10,000	$0·8 \times 10^6$	8,000	$0·64 \times 10^6$	74·2
Aluminium alloy	2·87	68,000	$10·5 \times 10^6$	23,700	$3·66 \times 10^6$	76·3
Magnesium-zirconium alloy	1·8	40,000	$6·3 \times 10^6$	22,200	$3·50 \times 10^6$	102·6
Titanium	4·4	190,000	$15·5 \times 10^6$	42,500	$3·52 \times 10^6$	56·7
Steel	7·85	100,800	$28·0 \times 10^6$	12,800	$3·57 \times 10^6$	38·7

Both chrysotile and crocidolite are capable of cleavage into extremely fine fibres ; the ultimate indivisible chrysotile fibre has a diameter as small as 200 to 300 Angstrom units, or 0·00000079in to 0·0000012in. Put another way, a chrysotile "fibre" having a diameter equal to a human hair—say, 0·0015in—would actually comprise a bundle capable of cleavage into about 1,900,000 separate fibres.

It is obviously impossible to segregate asbestos fibres into grades having precise lengths ; thus, any one grade will consist of a whole range of lengths down to dust. The grade of chrysotile used for high quality "Durestos" felts has a mean fibre length of about 0·35in, but, given suitable technique, high strength felts can be made from fibre having a much smaller mean length. This technique makes good use of the amazingly high-tensile strength of the fibre, which is between 100,000 lb to 240,000 lb per square inch for chrysotile and 100,000 lb to 320,000 lb per square inch for crocidolite. These figures compare with about 67,000 lb per square inch for mild steel and 300,000 lb per square inch for steel piano wire.

The material "Durestos," a proprietary material produced by Turner Brothers Asbestos Company, Ltd., has the strength and stiffness shown in Table I and an ultimate tensile strength of 30,000 lb per square inch is frequently obtained on test. Unfortunately, the type of asbestos from which "Durestos" is made does not exist in large quantities ; only a small fraction of the rock quarried yields asbestos having the characteristics essential for the highest strength. There are large quantities of asbestos potentially available for the industry, but the resultant plastic has a substantially lower strength than "Durestos." However, since the stiffness of this "second-grade" material is not much less than that of "Durestos," on the basis of $E^{\frac{1}{2}}$, it is eminently satisfactory for the appropriate range of aircraft, particularly if used in association with metal laminates.

The plastic may be moulded in a number of ways. The raw material is supplied in the form of felts, or flock, already impregnated with phenol-formaldehyde. Polymerisation starts and continues very slowly from the time the felt is impregnated, and after a maximum of, say, six months, depending on how the material is stored, it may become useless for its original purpose. On the application of pressure and heat after an initial "breathing" period, the molecular action is completed in a quarter of an hour or so. With heat only, the "cure" must take longer to permit the dispersion of water vapour without disruption of the fibre pattern ; with pressure it is possible to control this dispersion over a short period of time. It is appropriate in relation to these references that tribute should be paid to the work done at the R.A.E. in the development of this strong plastic.

A method of wide application for what may be termed non-structural parts is the "no pressure method," also first used by the R.A.E., in which the "felts" are laid on a plaster or other pattern, the cured product being then obtained by simply heating the material while it is so placed. Ductings for conditioned air, fairings, and parts generally which are subjected to low stresses are made in this way ; not only are tooling costs a minimum, but their weight is also a minimum, the density of the cured material being but 1·0 to 1·2 against 1·6 for parts of maximum strength, the saving of 25 to 30 per cent being, obviously, most important.

ASBESTOS FIBRES

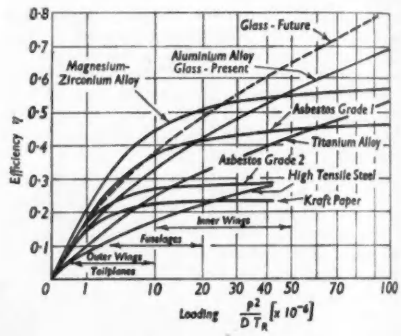
There are two particular varieties of "asbestos" which have great tensile strength and are used for the manufacture of high-grade moulding felts. One of these varieties is named chrysotile, and is more or less white in colour ; the other is crocidolite, which is blue. Both varieties are obtained by mining methods, chrysotile mainly from Canada and Africa, crocidolite from Africa and Australia.

After mining, the asbestos bearing ore is treated to eliminate all rock, also to separate the asbestos elements into grades according to their fibre length, and, finally, to condition the asbestos by opening up the bundles to produce fibres of the desired degree of fineness. The latter is of paramount importance and must be determined with due regard to the kind of manufacturing processes which the fibres have to withstand during their incorporation in the end product, in addition to the many technical considerations involved. For example, asbestos which is intended for manufacture into yarn must have sufficient individual fibre strength to prevent excessive breakage during the process of carding, because the strength of yarn produced will be a function of mean fibre length. On the other hand, asbestos moulding felts may be produced by methods which are much more gentle to the fibre, which can be pretreated so as to produce extremely fine fibres, technically suitable for production of felts in accordance with mathematical theories.

FIBRE PLASTIC

A study of Table I and Fig. 1 indicates the probable structural efficiency of glass compared with asbestos plastic. It will be seen that so far as the buckling criterion is concerned, over lightly loaded structures, glass plastic is slightly inferior to the asbestos plastics. On the other hand, for highly loaded structures, glass plastic covers an identical range to that of aluminium alloy ; so far as tension is concerned it is superior. The coincidence of the woven glass curve with aluminium alloy is remarkable. There are, however, greater difficulties in making a composite member from laminar metal and resined glass than from asbestos plastic ; this problem has to be overcome.

The position, so far as structure is concerned at present, is as indicated in Table I and Fig. 1, but there are certain things to be borne in mind



Skin stringer rib construction.
Z—section stringers.
F—0·88.
P—Compressive end load, lb/in.
D—rib depth, in.
T_R—Rib thickness, in.

Material		E, lb/in²	f_p lb/in²	C lb/in
Asbestos Phenolic Plastic	Grade 1	$2·8 \times 10^6$	18,000	0·0577
	Grade 2	$2·4 \times 10^6$	11,000	0·0577
Glass Polyester Plastic	Present	$2·2 \times 10^6$	34,000	0·0613
	Future	$6·0 \times 10^6$	150,000	0·0758
Aluminium alloy		$10·5 \times 10^6$	59,200	0·1035
Magnesium zirconium		$6·3 \times 10^6$	25,400	0·0648
Titanium alloy		$15·5 \times 10^6$	170,000	0·1585
High-tensile steel		$28·0 \times 10^6$	90,000	0·283
Kraft paper polyester Plastic		$0·8 \times 10^6$	7,000	0·0451

Fig. 1—Material Efficiencies in Compression Structures

* The Royal Aeronautical Society. February 26, 1953.
† Divisional director (aircraft), Bristol Aeroplane Company, Ltd.

with glass fibre. Unlike asbestos, it is not a natural product. It can be drawn to a very small diameter, 0·0002in or smaller. The difficulties which originally met the fibre producers may gradually be overcome without the use of highly expensive platinum crucibles which are still necessary for drawing the finest fibres.

Although in Table I 40,000 lb per square inch has been taken as the strength of woven glass laminate, the material is obtainable in forms giving much higher strengths—for example, as thread or as yarn—the difference being due to the imperfections introduced by weaving and the higher resin content on laminating.

With raw material as supplied at present with a resin content of 30 per cent the strength values of glass yarn impregnated with a suitable resin may be well in excess of 80,000 lb per square inch, with a density of 1·7, which is equivalent to 166 tons per square inch steel. If the fibres are laid at right-angles then the figures are halved, but that gives an equivalent of 83 tons per square inch, which may bear very heavily in favour of glass in the future, the point being that these fibres can be laid exactly where the designer wants them. That may not be done easily right away, but there appears to be no reason why any design requiring special orientation of fibre should not be obtained, given the time and money to develop the necessary machinery. There are good reasons for believing that the present value of E may be raised to 6 or 7×10^6, or, say, treble its present value. A curve for glass plastic having that value of E is shown dotted on Fig. 1 and it is clear that if such a value is realised eventually in works practice, as distinct from in the laboratory only, then aircraft design and construction will be revolutionised rapidly.

Apart from resistance to local damage, parts made from asbestos plastic in series production are cheaper than glass plastics, and 35 per cent lighter if the " no pressure " technique is suitable for the moulding of the part required. Where strength (necessitating higher pressure) is a requirement, then there is little in it in the matter of density.

It will be gathered that it is not possible at the present time to define strictly the fields of application of glass or asbestos plastic and that what at present is good respective practice with these materials may be out of date a year hence—a point which should be kept in mind.

So far as glass is concerned, what is needed is a cloth, yarn or fibre, pre-impregnated with resin before being made to conform to the moulding tool; glass fibre material so impregnated is likely to be available in quantity at an early date, but heat and pressure will be needed for curing this material. Further reference to this matter is made in the section on Resins.

Cellulose Fibre Plastic.—Hitherto the use of cellulose as a reinforcement has been attended by serious distortion troubles when laminated in conjunction with urea-formaldehyde or phenolic resins. This is because cellulose fibre absorbs water and swells, and neither of these resins forms a complete protection against water ingress.

More recent experiments with Kraft unsized paper, laminated with polyester resin and cured below 100 deg. Cent. to preserve the normal moisture content of the fibre, have shown distinct improvement. Immersion of such laminates in water for extended periods shows water absorption of only about 2 per cent and the attendant dimensional changes do not appear to be serious.

Preliminary results obtained from creped Kraft paper (25 per cent crepe) laminated with Marco 28*C* resin gave an average of 10,000 lb per square inch ultimate strength longitudinally, with 5000 lb to 6000 lb per square inch transversely. These strengths were associated with the low specific gravity of 1·1. The value for E derived from these tests is so far disappointing, being only $0\cdot75\times10^6$ lb per square inch longitudinally.

Resins.—A great deal still remains to be done with resins in relation to strong plastics. While their primary purpose is to bind the fibres together, they do not themselves contribute much to the tensile or shear strength of any structure, but in some degree they influence the stiffness properties of a laminate.

Broadly speaking, the phenolics show to greater advantage in this respect than do the polyesters, but this is accompanied by increased brittleness of the cured laminate. The gain is of the order of 50 per cent compared with a polyester-cured laminate.

Marco 28*C* is a typical example of a polyester resin which can be applied to large components which are normally cured in the open atmosphere without any special application of heat or pressure. At present there is no evidence to show that the use of either heat or pressure has any permanent effect upon the mechanical properties of polyester resin/glass cloth laminates and even if it did, it is probable that the cost of the tools and equipment for temperature and pressure curing would not be justified except in a few special cases, or when large numbers off were required. On the other hand, the shortening of the process time cycle might well justify that method of curing.

In the past, polyester resin had to be applied at the laminating and forming stage for glass, but quite recent developments in this country have resulted in the production of a modified polyester resin which can be used to pre-impregnate glass fabrics and mats. These pre-impregnated materials are simpler and cleaner to handle than similar materials impregnated with ordinary polyester resins, but unfortunately at present they suffer from the disadvantage that both pressure and heat are necessary to cure them.

The use of phenolics with glass is not new, since it has been used in the United States and in certain commercial applications in the United Kingdom. For normal insulation purposes, the phenolic resins are more liable to permit the access of water molecules to the glass, causing instability and deterioration of the insulation properties. Since the access of water to the glass could also reduce the mechanical properties, the use of phenolics has been regarded with suspicion, so far as glass is concerned, particularly since water is a by-product of phenolic resins during curing.

For radar use, it has been found that polyester resins are more transparent than phenolic resins to the exceedingly short wavelengths used nowadays for radar. Since the wider use of glass in aircraft sprang from its application to radar structures, it is not surprising that polyester resins have continued to be used in the aircraft industry since they provide, so far, the cheapest manufacturing technique. But, as already stated, this is intimately bound up with production requirements. If the numbers off are large, and other things are equal (for example, electrical transparency), then phenolics might be much cheaper than normal type polyesters, because of speed of production.

Foamed Resins.—There are considerable potentialities for a lightweight, thermally resistant foamed material, first as a medium to fill thin sheeted, lightly loaded structure, thus giving stability to the sheets and eliminating the use of internal metal stiffening; secondly, as a sandwich core material for radomes, the external surfaces of which are foamed from thin glass cloth laminates. In the second case, in addition to its mechanical properties, the electrical transparency of the foam is of importance.

A wide range of resins have been tested. The ideal final choice seems to be between two varieties of alkyd resins, one based on adipic and the other on sebacic acid, the foaming agent being a di-isocyanate. Rigid and otherwise satisfactory foams of this type can now be produced over a range of densities giving weights down to 3 lb per cubic foot. Experiments are in hand for establishing the techniques for pouring the prepared resins into various hollow shapes for the purposes mentioned, the compounded liquids foaming and setting *in situ*. As the isocyanates used in the process are toxic, special precautions are necessary when establishing the workshop technique.

Aluminium Alloys

It is hard to understand why more designers have not adopted the " Redux " process; it saves weight and cost, a good finish may be obtained through its use, and no enormously expensive new plant is needed.

Riveting is costly, particularly flush riveting, and especially that which gives a really smooth surface.

If " Redux " were chosen as the means of assembly of thick plates to reinforcing members of comparable thickness—say, both ¼in—then difficulties might arise if the pressure at cure was not sufficient to bring the metal at the glue line into real contact. Moreover, a new difficulty would have to be overcome in the matter of the correct temperature and pressure at the glue line if either the skin or stiffeners were tapered in thickness, which would certainly be the case for really large aircraft or one with high structural loading.

This latter problem should not necessarily be insuperable; while the temperature factor is very important and experimentation would be necessary in order to settle the number and disposition of the heating elements, it has been proved that perfectly good " Redux " joints can be obtained over a wide range of pressure, the essential thing on pressure being to ensure that the surface of the parts to be " Reduxed " are in good contact along their whole length at the time of lay-up before cure.

In the case of structure heavily tapered in plan view (thus achieving a constant load per inch chordwise along the span) and heavily reinforced with stiffeners, this method of assembly shows to advantage for aircraft of that type over, say, the integral machining of reinforcements from thick plates of metal.

The necessity, however, for machining large areas of wing surface from thick plates of aluminium alloy cannot be ignored. The necessity is with us now if only, perhaps, for special cases at present. But it is a matter of evolutionary experience in aircraft progress that the special case of to-day is the common requirement of to-morrow.

While in this paper emphasis has been laid on lighter structure, the continuous demand for higher speeds is forcing down thickness chord ratios which may well become, say, one-quarter only of the average ratio on what may be regarded as the standard civil aircraft of to-day. This will lead automatically to very thick wing root plating, heavily tapered and adequately stabilised; for this construction integral machining appears to be eminently desirable.

Magnesium Alloys.—Three years ago there seemed a good chance of the fairly early large-scale production of primary structures in magnesium alloy. The problem was the building of aircraft with exterior surfaces far smoother than anything yet done, except by expensive painting and polishing, and by far cheaper methods than could be achieved by riveting.

Fig. 1 indicates the excellence of magnesium alloy over a wide range of structural application, and much experimental work has been done on fabricating and ascertaining the physical and mechanical properties of magnesium alloy structure.

" T " extrusions are automatically and continuously butt welded, either to each other in the case of Ts having wide, straight-through flanges or, if these cannot be obtained with sufficiently wide tops, then the extrusions are interconnected by means of plate of appropriate width and thickness. All welds are made at one pass; ¾in is the maximum thickness of material butt welded with existing equipment at one pass, with complete penetration.

Transverse or chordwise welds follow those spanwise. The thickness of the plates decreases towards the wing tip and the inner and, therefore, thicker plate at any chordwise abutment is machined down over a width of ½in or so to the thickness of the thinner adjoining plate, thus making the chordwise weld possible. The inwardly extending flanges at these lines of chordwise welding are either bolted or riveted together by the use of fish plates, this feature being also associated with the attachment of the shear members which may be either plate or open Warren type bracing. Before that, however, when all the welding is finished, the exterior weld beads are milled off and then each completed surface is bent to contour under heat between appropriate blocks (shaped to the wing contour) in a drop hammer of adequate size and tup weight.

Riveting is not entirely eliminated by the foregoing methods, but probably 90 per cent of it could be eliminated with the attainment of a completely smooth surface.

From the aspect of fabrication costs alone, the methods of assembly described would show great

savings over structure completely assembled by riveting.

It might be added that tungsten arc automatic welding has been tried on high strength aluminium alloy and the welds were even better than those in magnesium alloy, but while the full static strength of the parent aluminium alloy metal was obtained at the welds after heat-treatment, such fatigue tests as have been done have shown the material near the welds to considerable disadvantage, compared with the parent metal. Again, the restoration of the full static strength by heat-treatment of a complete welded wing structure is not a task one would care to contemplate.

Titanium

In a paper such as this something should be said on titanium, but a brief comment is all that is needed.

The biggest advantage lies with the designer who is concerned with the installation of gas turbine power plants, particularly where the hottest parts pass through the wing or fuselage structure. Because the structural aluminium alloy should not be subjected to temperatures much in excess of 150 deg. Cent., he is forced to use stainless steel for structural parts where this temperature may be exceeded, similarly for bulkheads, fairings and the like. But even with titanium, a temperature of 600 deg. Cent. should be the limit for this purpose. The total saving in replacing steel in some aeroplanes for these parts is surprisingly large.

The engine designer, particularly, has something to look forward to when the material becomes available and at a reasonable price; the savings in weight in jet pipes, shrouds and many internals should prove to be really substantial.

Road Surveys with Gyroscopic Equipment

(By our American Correspondent)

RESEARCH work conducted by the California Highway Planning Survey Section of the State Department of Public Works in conjunction with the Sperry Gyroscope Company, of San Francisco, has resulted in the development of an interesting gyroscopic surveying instrument and technique which allows the alignment and grades on existing roads to be obtained accurately and rapidly. The equipment has been used successfully in California during the past few months in the survey of more than 4000 miles of State highways. The grade and alignment data, which are thus obtained, are being made available to the American Automotive Safety Foundation for inclusion in a report on California highway deficiencies which the foundation is compiling for the California State Legislature.

The equipment involved is mounted in an estate car and comprises an odometer, reading to a thousandth of a mile, and two gyroscopes, one being installed horizontally and one vertically to make possible the measurement of azimuths to the nearest degree and the measurement of grades and superelevations to the nearest per cent. The accompanying illustrations, respectively, show the survey car with the gyroscopic equipment in the operating position and the indicating instruments mounted in front of the driver's seat. The odometer works from a junction off the regular speedometer connection and has a reset, preset and a back-up registering dial. The horizontal gyroscope is devised so that it indicates azimuth to the nearest degree. It has a declination adjustment so that for a given locality it can be set to register true azimuths. The vertical gyroscope is an adaptation of that used in the automatic landing control mechanism of aircraft. The phenomenon of precession in this unit is controlled by two level bubbles mounted parallel to each of the two gimbals of the gyroscope. Through a system of induced voltages, current is caused to be circuited through two finely adjusted voltmeters when the car body deviates from the horizontal plane. The amount of the deviation is measured in per cent of grade and superelevation. The combination of these three instruments makes possible the measurement of distances to the nearest 1/1000 mile, azimuths to the nearest degree, and grades and superelevations to the nearest per cent. Supplementary installations in the vehicle consist of a 110V, 750W generator to supply the electric current necessary to operate the gyroscopes, a converter to change the frequency of the electric current from 60 c/s to 400 c/s, a voltage regulator to maintain a steady flow of current to the registering dials, two inclinometer tubes to make initial settings of the vertical gyroscope and to facilitate quick intermediate checks at frequent stops, and an aiming device installed on the front bumper to aid in setting the car in the correct position for an azimuth or generalised grade reading.

In the operation of the vehicle, recordings are taken that indicate the odometer location of the beginnings and endings of all curves and tangent sections; the azimuth reading of each tangent at points of compounding or reversing of curves; the superelevation of each curve encountered; the odometer location of the estimated points of intersection of extended grades; the percentage of grade between those points, and such notes as may be judged necessary for the use of the draughtsman in delineating the final line traversed. These notes are given to the punched card tabulating machine section of the Planning Survey, where they are processed mechanically and where tabulations are made showing, in addition to the recorded data, the azimuths chords of curves in degrees and half-degrees; central angle of curves, in degrees; intervening distances (lengths of tangents or curves) in 1/1000 mile; lengths of chords of curves, in 1/1000 mile; radii of curves, in feet; safe driving speeds on curves, in miles per hour; progressive departures, or X-co-ordinate values,

A—Odometer. *B*—Horizontal gyroscope. *C*—Superelevation and grade dials. *D*—Inclinometer tube.

Survey Indicating Instruments

in 1/1000 mile; progressive latitudes, or Y-co-ordinate values, in 1/1000 mile; and grade profile or elevations, in 1/10 ft. The above data are then plotted to a scale of 10in to 1 mile, resulting in a plan and profile of the traversed road. Experience gained in the operation of the vehicle indicates that accuracies of 0·2 per cent may be expected in the odometer distances taken and of 0·5 to 0·9 per cent on the closure of the traverses calculated, and that grades can be reliably estimated to within 0·5 per cent; that the field operation phase of the survey can be done at a rate of about 5 m.p.h.; that the combined costs of operating the equipment in the field and of processing the field notes mechanically are well under 10 dollars per mile of road traversed, and that the time taken to plot the tabulations and to prepare a reproducible copy varies considerably, depending on the topography. Early figures indicate that a mile can be plotted and tracings made in about 3 hours.

The accuracy of the results of the "gyro traverse", which is the name that has been given to this surveying technique, indicates that it compares favourably with the accuracies that might be expected of the more conventional method of stadia survey. The applications of this method have so far been confined to the preparation of a plan and profile plot of such state highways that have never been formally surveyed; to the establishment of a key net of roads within a county as a basic net for road inventory mapping, and to the rapid supply of statistical data on alignment and grades of certain routes at much less expense and time than would be required to review the existing plans.

Survey Car

Industrial and Labour Notes

Full Employment

On Wednesday of last week there was a debate in the House of Commons on development areas and the distribution of industry. Winding it up on behalf of the Government, Mr. Harold Watkinson, Parliamentary Secretary to the Ministry of Labour, dealt with the subject in its particular relation to the question of full employment.

In the course of his speech, Mr. Watkinson said that, obviously, we had passed out of the post-war phase of shortages and sellers' markets and were now having to consider a full employment policy in the light of severely competitive conditions. In those circumstances, more rapid shifts and changes in the month-to-month employment and unemployment figures must be expected. But, Mr. Watkinson added, no Government should allow itself to be diverted from its long-term objective planning by panic over every pool or pocket of transitional local unemployment. To get the thing right it was essential to stick to the main plan.

Mr. Watkinson went on to say that the Government recognised the primary responsibility to get the economic background right. One special matter to which it attached great importance was the work of the British Productivity Council, the main job of which was to get the "know-how" and "know-why" of productivity right down to the shop floor level, where it would do most good, and right into the smaller factories. Another matter of importance, Mr. Watkinson continued, was the creation of stable conditions in the delicate balance between wages and prices. The Interim Index of Retail Prices, on which the wages of 2,000,000 people depended and on which the whole wages structure also largely depended, had now been stable at 138 or below for seven months, which was the longest period since the index was started. It was hoped that within that framework of stability a level balance on wages could be kept. Mr. Watkinson said, however, that in asking for restraint in wages the Government wanted to make it quite plain that it did not ask in any way for restraint in earnings. If earnings could be linked with output, the more a man earned the better it would be for him, for his employer and for the country as a whole.

Index of Industrial Production

The index number of industrial production (1948=100), which is prepared monthly by the central statistical office of the Treasury, has been estimated provisionally as 111 for all industries in December last, compared with 122 in November. The corresponding figures for 1951 were 113 in December and 123 in November. Taking the whole year 1952, the index for all industries has been provisionally estimated as 114, compared with 117 for the year 1951. The Treasury says that, on the basis of information so far received, the index for all industries for January, 1953 is expected to be 117 or 118.

Double Day Shift Working

The National Joint Advisory Council, which consists of representatives of the British Employers' Confederation, the Trades Union Congress and the nationalised industries, held its quarterly meeting in London on Wednesday, February 25th, under the chairmanship of the Minister of Labour, Sir Walter Monckton, Q.C. One of the matters considered was the desirability of seeking an extension of double day shift working.

According to an official statement issued after the meeting, there was no suggestion that there should be an immediate change to double shift work, as, in general, British industry is equipped for single shift working. The council considered, however, that the introduction of shift working would be of great value where the circumstances were particularly favourable, such as where a firm had expensive plant and equipment lying idle for the greater part of the twenty-four hours, and markets and labour could be found to enable that plant to be brought into productive use. The council thought that a change over to double day shift working might be desirable in these circumstances, and also where an extension to a factory on single shift was proposed in order to increase output, or where there was need for modernisation and re-equipment in order to improve competitive efficiency. At the same time, the council emphasised that double day shift working was a matter for the individual firms concerned in consultation with their workpeople. It was recommended that firms should be encouraged to examine their costs and see for themselves whether and to what extent there would be economic advantage by arranging double day shifts.

Other matters before the council included suggestions made to encourage the further development of good human relations in industry, and an appreciation of the economic situation. The latter reviewed the manpower position and also considered the trends of overtime and short-time working. Note was taken of the latest increase in the price of coal and of its possible effect on other basic industrial and manufacturing costs. The council agreed that something should be done to create a sense of urgency about the country's economic problems, including particularly the need for greater exports.

Changes in Wage Rates

A report by the Ministry of Labour says that changes in wage rates, which came into operation in January, resulted in an aggregate increase of about £150,000 in the weekly full-time wages of approximately 788,000 workpeople, and in a decrease aggregating about £2300 a week for 62,000 workpeople. The decreases operated under sliding-scale arrangements based on the index of retail prices.

The Ministry of Labour says that of the total weekly increase in wages of £150,000, about £55,000 was the result of arbitration awards. About £42,000 resulted from direct negotiations between employers and workpeople or their representatives, and approximately £27,000 was the result of the operation of sliding scales based on the index of retail prices. The remainder of the wage increases in January resulted from arrangements made by joint industrial councils or similar bodies, and from Orders made under the Wages Councils Acts.

The F.B.I. and the Budget

The Federation of British Industries has issued a memorandum setting out the representations on Budget policy which it has made to the Chancellor of the Exchequer. It says that, while important remedial measures of a first-aid character have been taken by the Government, the condition of the British economy remains precarious, and unless further measures of a long-term character are taken, British industry is likely to run into still more serious difficulties.

The F.B.I. considers that the primary object of further measures should be to reduce costs and increase productivity in order to improve the competitive ability of British industry in overseas markets. It is difficult to see how this result can be achieved, the memorandum continues, unless (*a*) the Government materially reduces its expenditure so that, without creating conditions conducive to inflation, it can take a much smaller proportion of the national income in taxation; (*b*) better financial incentives are provided for work and enterprise; (*c*) incentives and opportunities are also provided for more savings by individuals; and (*d*) firm measures are taken to enable capital reserves for the re-equipment of British industry to be built up. The Federation advances the view that the main discouragement to work and enterprise is now felt in the medium and higher ranges of income. It is important, the memorandum says, that the enthusiasm and drive shown by individual proprietors, by executives and by industrial management at all levels in other countries, such as the U.S.A. and Germany, must be matched in this country where there is at present much frustration. The severe burden of taxation is a serious handicap to the management and development of British industry and, the F.B.I. considers, is likely to endanger the spirit of enterprise which is so necessary in the hard competitive conditions of to-day.

Another matter to which attention is directed in the memorandum is that the capital employed per worker in British industry is much below that of workers in the U.S.A. That is stated to be one of the major factors accounting for the higher productivity per worker in the U.S.A. In 1951, so far from catching up, British industry fell further behind. The amount of additional capital invested in American industry per worker was ten times that of the additional capital invested per worker in this country. The memorandum stresses that urgent action is necessary to remedy the unsatisfactory basis for the allowance of depreciation of fixed capital and the valuation of working stocks if, in this matter, British industry is not to fall still further behind its American and German competitors.

The Federation asserts that the method of taxing industrial profits is only one of the evils which industry suffers at the present time. The other evils, its memorandum says, are the very high rates of taxation, and the tax discrimination against income derived from industry and enterprise which both the profits tax and the excess profits levy represent. The Federation maintains its view that this discrimination against the form of income which is most necessary for the maintenance of the health of British economy is entirely unwarranted and unsound.

Industrial Disputes

The Ministry of Labour has reported that during January there were in progress in the United Kingdom 140 stoppages of work which arose through disputes in industry. Of that total, four started prior to the month of January. The number of workers involved in these 140 stoppages in January was 24,100, and the aggregate number of working days lost has been put at 60,000. The coal mining industry accounted for 103 of the total number of work stoppages, and as a result of them 35,000 working days were lost.

It is stated that of the 130 stoppages of work which ended in January, seventy lasted not more than one day; thirty-one lasted two days; fourteen lasted three days; twelve lasted from four to six days; and three lasted more than six days.

Coal Production

Coal output in Great Britain last week amounted to 4,618,300 tons, of which 4,377,300 tons came from the deep mines and 241,000 tons from opencast workings. The total production was 58,000 tons or so greater than in the preceding week. In the first eight completed weeks of this year coal production totalled 36,750,900 tons, compared with 36,431,400 tons in the corresponding period of last year.

A statistical statement issued by the Ministry of Fuel and Power includes figures of colliery manpower and productivity for the week ended February 21st. In that week the number of wage-earners on colliery books was 720,700, of whom 299,600 were face workers. A year earlier the total number of workers was returned as 708,300, of whom 288,500 were employed at the face. The number of shifts worked per wage-earner in the week ended February 21st was 4·92, compared with 5·08 in the corresponding week of 1952. Absenteeism was 14·21 per cent, against 12·09 per cent in the comparable week of last year, and the output per manshift at the face was 3·17 tons.

Coal consumption, including export and bunker requirements, amounted to 4,929,000 tons in the week ended February 21st. Distributed stocks at the end of that week totalled 13,136,000 tons.

Notes and Memoranda

Rail and Road

A CINEMA COACH FOR BRITISH RAILWAYS.—To meet the increasing requirements, especially at outlying places, for displaying staff instructional films, British Railways has put into service a second cinema unit. The unit comprises a cinema coach and a second vehicle for carrying the electric generating equipment. The coach seats fifty-two and the projector is housed in a partitioned projection-room behind the auditorium.

NEW GOODS DEPOT AT LIVERPOOL.—Work is now in progress on the construction of the new £200,000 goods depot at Huskisson, Liverpool. This new depot, which will be one of the most modern in the country, will enable British Railways to deal with goods more speedily and efficiently. With the method of handling devised, packages will be taken from the wagons and placed on an electric conveyor. Packages for town handling will be taken off the conveyor at appropriate points and loaded on to road delivery vehicles. Traffic requiring to pass through the warehouse or to "wait order" will be taken off the conveyor at a dock provided for this purpose adjoining the shipping warehouse.

VEHICLE REGISTRATION AND LICENSING.—New regulations for the registration and licensing of motor vehicles have been made by the Minister of Transport and came into force on February 28th. These regulations give effect to the recent decision that as supplies of registration marks under the present system become exhausted letters will be placed after the numbers instead of in front. The first registration marks to be issued under the new system will be for vehicles registered in Middlesex and Staffordshire and, later in the year, vehicles registered in Essex will have the new marks. It will be some time before supplies are exhausted in other parts of the country and, until this happens, other registration authorities will continue to assign registration marks with the numbers after the letters. Any combination of letters following the numbers in the new system will represent the same registration authority as it did when preceding the numbers. Under the new regulations, registration authorities may be required to supply particulars of vehicles fitted with wireless sets to the Postmaster-General. Another change made by the regulations is that a broken-down vehicle drawn by a vehicle which is being used under a limited trade licence may carry a passenger. The new regulations require that, when a vehicle is produced at a weighbridge for weighing it shall be produced with any alternative or additional body or parts which, by virtue of Section 26 of the Vehicles (Excise) Act, 1949, are required to be included in the unladen weight of the vehicle. Copies of the regulations may be obtained from H.M. Stationery Office, price 1s.

Miscellanea

OIL SEARCH IN SICILY.—The D'Arcy Exploration Company has completed geological and gravity surveys for oil in Sicily and is at present engaged on a seismic survey.

THE ROYAL SHOW, 1955.—The council of the Royal Agricultural Society of England has accepted an invitation to hold the 1955 Royal Show at Wollaton Park, Nottingham. The last occasion on which the show was held in Nottingham was in 1928.

KENT REFINERY.—The distillation unit at the Kent oil refinery, on the Isle of Grain, owned by the Anglo-Iranian Oil Company, Ltd., is now on stream, and the next stage is expected to take place this summer when the catalytic cracker and its associated plants are completed.

MANAGEMENT AND THE PLANT ENGINEER.—The sixth annual conference of the Institution of Incorporated Plant Engineers is to be held at the Palace Hotel, Southport, on May 20th, 21st and 22nd. The discussions will be devoted to the general theme of "Management and the Plant Engineer."

DEATH OF MR. J. S. SMITH.—We have learned with regret of the death of Mr. John Satchell Smith, which occurred in hospital in Liverpool on February 21st. Mr. Smith, who was sixty-four, was formerly manager in the North-Western area of the Marconi International Marine Communication Company, Ltd.

THE LATE MR. J. A. PETERS.—We have learned with regret of the death of Mr. James Arthur Peters, which occurred on February 18th. Mr. Peters, who was sixty, was managing director of Petbow Ltd., Sandwich, Kent, which firm he established in a small workshop at Willesden just over twenty-one years ago.

JUBILEE OF THE INDIAN CONCRETE JOURNAL.—We learn from the January issue of the *Indian Concrete Journal*, that that journal and also the Concrete Association of India celebrated their twenty-fifth anniversary in January. The importance of concrete construction in India to-day, with its many large power and irrigation projects under construction as well as important constructional works of other kinds, is well exemplified by the various articles in the "Jubilee" issue of the journal.

A RIGHT-ANGLE DRIVE GEARED MOTOR.—A ¼ h.p. geared motor (type "SW") with a right-angle drive, final speeds ranging from 270 r.p.m. to 0·055 r.p.m., and suitable for floor, wall and ceiling mounting, has been introduced by the Normand Electrical Company, Ltd., North Street, Clapham Common, London, S.W.4. It can be wound for the normal a.c. and d.c. voltages and it produces a torque of 25 lb-ft at the final shaft at speeds up to 14·8 r.p.m. At higher speeds the output is limited by the limit of ¼ h.p. available at the motor shaft.

AIR SEARCH FOR OIL.—Hunting Geophysics, Ltd., is conducting an airborne magnetometer survey of a large area in Papua for the purpose of producing a regional magnetic map. From this the geologists and geophysicists of the prospecting oil companies, including the Anglo-Iranian Oil Company, Ltd., will determine suitable areas for ground prospecting.

THERMODYNAMICS AND REFRIGERATION.—Three lectures on "Some Problems in Thermodynamics and Refrigeration" are to be given by Professor Rudolf Plank, at King's College, Strand, London, W.C.2, on Monday, Wednesday and Friday, March 9th, 11th and 13th, at 5.30 p.m. The lectures, admission to which is free, are addressed to students of the University of London and to all others interested in the subject.

LECTURES ON CORROSION TESTING.—A course of six lectures on "Corrosion Testing" is to be delivered at the Northampton Polytechnic, St. John Street, London, E.C.1. The first lecture, by Mr. S. C. Britton, has been fixed for Wednesday, March 18th, at 7 p.m., and the succeeding lectures will be given on Tuesday evenings, March 24th, April 14th, 21st, 28th and May 5th, at 7 p.m. The fee for the complete course is £1.

AUSTRALIAN OIL REFINERY.—The construction of the oil refinery at Geelong, near Melbourne, for the Shell Petroleum Company, Ltd., is well advanced and is expected to be completed by June, 1954. It is designed for an output of more than 1,000,000 tons per annum and the products will be delivered to Melbourne by an 8in diameter pipeline. To handle the incoming crude oil the port approaches at Geelong are to be dredged to accommodate general purpose tankers of 18,000 tons.

INDUSTRIAL DIAMOND TRADE NAMES INDEX.—The fourth edition of the "Industrial Diamond Trade Names Index, 1952–53" which has just been published, lists some 1900 trade names of diamond tools, abrasives, sintered carbides, &c. Included in the trade names are generally used abbreviations and names of firms which have a special standing in the trade. The book is published at 3s. 6d. net by the Industrial Diamond Information Bureau, 32–34, Holborn Viaduct, London, E.C.1.

WOLVERHAMPTON'S WATER SUPPLY.—The Wolverhampton Town Council's Water Committee has decided to begin the preliminary work for the provision of an additional source of supply. A survey in 1951 indicated that Stableford was a suitable site for pumping underground water to give a yield of about 3 m.g.d., and the water engineer has been authorised to approach landowners with a view to testing the suitability of the site for the quantity and quality of the yield. At present the consumption of water in Wolverhampton is about 9·9 m.g.d. and the yield from present sources some 10·7 m.g.d.

THE SOCIETY OF ENGINEERS.—At a meeting of the Society of Engineers held on Monday, March 2nd, a paper entitled "Developments in the Recovery of By-Products from Coke-Oven Gases" was presented by Messrs. C. L. Boucher and D. Bagley. The paper refers to developments in the recovery of ammonia and ammonia products and the production of sulphuric acid from the hydrogen sulphide content of the gas. Developments in benzol production are mentioned and there are comments on the future place of methane in industry, together with a suggestion for research into the uses of this constituent of coke-oven gas.

CORYTON REFINERY.—Part of the daily supply of 45,000,000 gallons of cooling water required by the Coryton Refinery of the Vacuum Oil Company, Ltd., will be used in the refinery plant and will return to the river upstream of the refinery. To carry the cooling water clear of the sea wall bounding the site, a channel, 200 yards long by 6ft deep, has been hollowed out across the foreshore to low-water level by blasting away the soft mud. It is expected that the surge of the discharged cooling water, amounting to about 15,000,000 gallons per day, will be sufficient to keep the new channel in being without having recourse to the use of concrete or other lining.

THE FLOODING OF CORYTON REFINERY.—We have received from the Vacuum Oil Company, Ltd., a booklet describing the recent flooding of Coryton refinery and the subsequent repair work. On January 31st last the refinery was scheduled to go "on stream," and the finished product was coming through the crude distillation unit for the first time at four o'clock on that day. At one o'clock the following morning the protective dyke was breached and the sea flooded in; the plant was successfully shut down within fifteen minutes. 4000 men were at work by Monday morning and in forty-eight hours 200,000 sand-bags had been filled and placed in position. No serious damage had been done to the refinery plant and in twenty-one days it was again "on stream."

WASTE HEAT RECOVERY FROM DIESEL GENERATORS.—An interesting new film entitled "The Diesel Generator as a Composite Heat and Power Unit," made for Shell Mex and B.P., Ltd., was shown in London last week. This film describes how heat can be recovered from the cooling and exhaust systems of diesel-driven generator sets and used for domestic or industrial purposes. It points out that the efficiency of a diesel generator set may be as high as 37 per cent and how, by the recovery of heat from the cooling water and exhaust, the total efficiency of a plant can be raised to 81 per cent. After giving a graphic outline of the theory and basic methods of heat recovery, the film shows five modern plants—a country house, a film studio, a department store, a tannery and a cotton weaving mill—where heat recovery systems are being used to good effect.

LEAD CYANAMIDE ANTI-RUST PIGMENT.—The anti-rust pigment, lead cyanamide "DK825," manufactured by the Duisburger Kupferhutte, is being imported from Germany and some British paint manufacturers are now making primers based on the pigment. This pigment is actively anti-rusting and it transforms acidic atmospheric products, such as carbon dioxide, sulphur dioxide, hydrogen sulphide and the acid decomposition products of linseed oil, into non-corrosive compounds. The cyanamide split-off under the influence of acid, due to its tendency to form ammonia, has an alkaline passivating action with water, which remains unimpaired over many years. The low specific gravity and the considerable bulking volume, due to the crystal structure of lead cyanamide are claimed to confer valuable technical properties upon ready-mixed paints. There is practically no settling in the paints, whilst, in spite of ready soap formation, lead cyanamide, when incorporated in paint, shows practically no tendency to thickening, the reaction not beginning until oxygen has access to the applied coat. This property gives good "can life" to paints, and there is no waste of material due to paint residues becoming unfit for use.

Personal and Business

MR. J. R. HAMMOND, A.M.I.C.E., has been appointed district engineer, Wolverhampton, in the Western Region of British Railways.

DR. W. L. LOWE-BROWN, M.I.C.E., 39, Victoria Street, London, S.W.1, states that he is retiring from his consulting engineering practice on March 24th.

THE PACIFIC STEAM NAVIGATION COMPANY announces that Mr. J. J. Gawne has been appointed secretary of the company in succession to Mr. J. T. Ford, who has retired.

B.E.L.A. MACHINE TOOL, Ltd., states that its address is now 873–879, Old Kent Road, London, S.E.15 (telephone, New Cross 5091; telegrams, "Belalon, Peck, London").

JOHNSON AND PHILLIPS, Ltd., Charlton, S.E.7, states that Mr. A. Upton, manager of its switchgear department since 1947, is resigning shortly to take up an appointment in the U.S.A.

AVELING-BARFORD, Ltd., Grantham, announces the appointment of Mr. J. L. Ritchie, A.M.I.Mech.E., as general sales manager, and of Mr. G. M. Warren as export sales manager.

LONDON TRANSPORT states that Mr. D. McKenna, at present commercial manager, has been appointed chief commercial and public relations officer. Mr. H. W. Brooksbank has been appointed fares and charges officer.

MR. W. D. WHEELER, A.M.I.E.E., has joined Messrs. Kennedy and Donkin, consulting engineers, as their chief representative in South Africa. He will take charge of the firm's office at 22, Amershoff Street, Braamfontein, Johannesburg.

MUSGRAVE AND CO., Ltd., Belfast, states that its London office has been moved to 2, Howard Street, Strand, W.C.2 (telephone, Temple Bar 2061). The firm's Newcastle office has been moved to 34, Great North Road, Newcastle upon Tyne, 2 (telephone, Newcastle 26311).

STEWART BROTHERS (LONDON), Ltd., Albert Road North, Reigate, Surrey, has established a service station for the fork lift trucks and tractors manufactured by the Clark Equipment Company, Battle Creek, Michigan, U.S.A. This latter company's official distributor for the United Kingdom is Aglo, Ltd., Imperial House, Dominion Street, London, E.C.2.

MARCONI'S WIRELESS TELEGRAPH COMPANY, Ltd., announces the appointment of Mr. Robert Telford, A.M.I.E.E., as general works manager of all its works and model shops. Mr. J. P. Wykes, A.M.I.E.E., will continue as works manager of the Chelmsford works, and Mr. E. B. Greenwood, A.M.I.E.E., has been appointed works manager of a factory now being built at Basildon, Essex.

LANCASHIRE DYNAMO HOLDINGS, Ltd., states that the address of its registered office is now St. Stephen's House, Victoria Embankment, London, S.W.1 (telephone, Whitehall 7211). At this address there are also now established the London sales office and export department of Lancashire Dynamo and Crypto, Ltd. (telephone, Whitehall 7211); the export and London and Home Counties sales office of Lancashire Dynamo Switchgear, Ltd., and Crypton Equipment, Ltd. (Whitehall 2751), and the office of the Lancashire Dynamo Group publicity services (Whitehall 2751).

Launches and Trial Trips

LANG, benzene lighter; built by Philip and Son, Ltd., for the Shell Company of Singapore, Ltd.; length between perpendiculars 132ft, breadth 24ft 6in, moulded depth 9ft 7½in, cargo capacity 306 tons of benzine; Crossley "H.R.N.5" diesel engine, 470 b.h.p. at 400 r.p.m., two 79 tons per hour diesel-driven cargo pumps. Trial, February 17th.

BEAVERBANK, cargo liner; built by Harland and Wolff, Ltd., for the Andrew Weir Shipping and Trading Company, Ltd.; length between perpendiculars 425ft, breadth moulded 59ft, depth moulded to shelter deck 38ft 3in, gross tonnage 5800; two steel decks, eight watertight compartments, four main cargo holds, two deep tanks; Harland and Wolff-B. and W. two-stroke, single-acting, opposed-piston diesel engine, six cylinders, 620mm diameter by 1870mm combined stroke, 118 r.p.m., two vertical boilers, three 175kW diesel-driven generators. Trial, February 25th.

British Patent Specifications

When an invention is communicated from abroad the name and address of the communicator are printed in italics. When an abridgment is not illustrated the specification is without drawings. The date first given is the date of application; the second date, at the end of the abridgment, is the date of publication of the complete specification.

Copies of specifications may be obtained at the Patent Office Sales Branch, 15, Southampton Buildings, Chancery Lane, W.C.2, 2s. 8d. each.

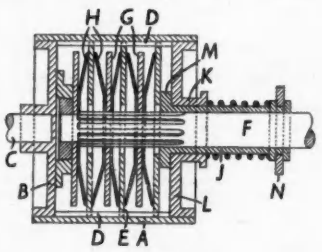
ELECTRICAL ENGINEERING

687,202. October 27, 1949.—ELECTROMAGNETS, Ole Ellefsen, 10, Seymour Avenue, Heysham, Lancashire; and The Morecambe Electrical Equipment Company, Ltd., Westgate Works, Morecambe, Lancashire.

The invention provides means to avoid the undesirable "cling" or failure of the armature or plunger to move or open when the energising current is cut off. According to the invention, a small electrostatic condenser is connected across the main or auxiliary coil of an electromagnet energised by alternating or direct current. The capacitance of the condenser may vary within wide limits. In the case of an electromagnet having a coil of 3000 turns and a core cross-section in the coil of 0·43 square inch, energised by alternating current of 400V, 50 c/s, capacitances between approximately 0·03 and 2 microfarads were found to be effective. The condenser has a suitable small value such that it does not delay the opening of the relay, but discharges almost instantaneously and tends to become oppositely charged so as to cause a reverse current in the coil, which has a demagnetising effect on the iron core. No reversing switch is needed.—*February* 11, 1953.

687,269. January 26, 1949.—MAGNETIC CLUTCHES, Walter George Wareham, 37, Grass Royal, Yeovil, Somerset.

The invention relates to a magnetic clutch which is silent in operation and reduces loss of power to a minimum. Referring to the drawing, the clutch consists of a cage *A*, which has an end plate *B* bolted to its outer end, to which is connected one end of a driving shaft *C*. The cylinder has on its inner face longitudinal splines *D*, which engage the peripheries of three permanently magnetised driving discs *E* driven by the cage. Within the cage is a driven or secondary shaft *F*, which is splined and has three driven permanently magnetised discs *G*, which alternate with the driving discs *E*. The individual driving and driven discs alternate with their opposing faces of opposite polarity. In operation the permanently



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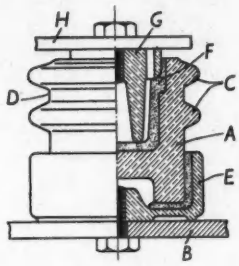
magnetised driving discs *E* drive the permanently magnetised driven discs *G* by reason of the magnetic drag of the driving discs *E*. The speed ratio is varied by varying the effect of the magnetic drag, and this is done by interposing between the alternate discs yieldable means which will permit the discs to be moved closer together and which, when released, will move the discs further apart. They may comprise a star-shaped spring *H* or a spring having a hub provided with a multiplicity of radial arms which extend to one side of the plane containing the hub of the spring. A sleeve *J* is supported for axial movement in a collar or bearing *K* formed integrally with the inner end plate *L*, which is secured to the other end of the cage and the innermost end of this sleeve is fitted or formed with a thrust block *M*, which bears against the first or end driving disc so that it is moved axially and in so doing compresses the yieldable spring between itself and the next driven disc and so on through the series of discs. Variation of the distances apart of the discs varies the effect of the magnetic drag on the driven discs. The sleeve *J* can be slid axially by means of an actuating shoe *N* connected with the sleeve externally, the sleeve being moved against the influence of a coiled compression spring. The interior of the sleeve is not splined and does not rotate with the shaft.—*February* 11, 1953.

684,991. August 2, 1950.—ELECTRIC INSULATORS, Siemens-Schuckertwerke Aktiengesellschaft, Siemensstadt, Berlin, and Sieboldstrasse 5, Erlangen, Bavaria.

The drawing shows a supporting insulator *A* mounted upon a supporting bar *B*. The insulator is of substantially H-shaped cross section and is provided with two laterally extending petticoats *C*, having between them a deep groove *D* for delaying the effect of soiling. An external flange *E* is mounted on the lower end of the insulator and is secured by a cement which does not expand upon increase of tem-



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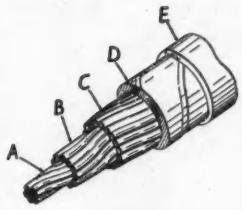
perature and which does not crystallise. The skirt of the flange *E* is of sufficient height to enable it to be secured to the insulator, whilst at the same time providing considerable strength. The insulator body has at the lower end a cylindrical cavity. Owing to the low overall height, however, the height of the cylinder wall at this point is not sufficient to ensure sufficiently flexible support of an internal flange. Formed in the upper end of the insulator body is a recess *F*, in which an internal flange *G* is fitted and secured, for example, by cementing, the flange in turn supporting a bus-bar *H*. In most cases such supporting insulators are supported at the lower end, so that it is expedient to provide the external flanges at the lower end of the insulator. With an insulator designed as shown low overall heights and spacings are sufficient with a prescribed dielectric strength, particularly for voltages of up to 6kV.—*December* 31, 1952.

687,084. August 29, 1950.—OVERHEAD ELECTRIC LINE AND CONDUCTOR, British Insulated Callender's Cables, Ltd., Norfolk House, Norfolk Street, London, W.C.2 (*Inventors: Leslie Giddens Brazier and William George Hawley.*)

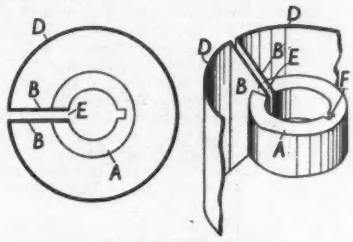
The invention relates to overhead electric transmission lines working at high voltages. Referring to the drawing it will be seen that the example shown comprises a central member with a central core *A* consisting of seven wires of which six are laid up helically around a seventh to form a seven-wire strand. They are of steel or other metal of high tensile strength. Surrounding the core is a layer *B* of twelve wires of metal of good electrical conductivity, preferably a light metal such as aluminium. They are laid up helically about the central core with a direction of lay opposite to that of the core wires. Around this layer is a second layer *C* of eighteen similar wires which are laid up helically about and preferably in the opposite direction to the wires of the underlying layer *B*. The core and its two surrounding layers of conductor wires constitute the central member of the overhead line conductor. Surrounding the metallic central member is a continuous covering *D* of non-metallic material. Closely fitting the covering and forming a complete enclosure for the rest of the conductor structure is an outer conductor consisting of a thin-walled tube *E* of a light metal of good electrical conductivity, such as aluminium or an aluminium rich alloy. The tube has a circumferentially continuous wall with a smooth circular outer surface. The specification also shows a modified form of construction and a standard form of jointing.—*February* 4, 1953.



No. 687,084

682,684. October 3, 1949.—HIGH-FREQUENCY ELECTRIC INDUCTION HEATING APPARATUS, The General Electric Company, Ltd., Magnet House, Kingsway, London, W.C.2; and Reggie Smith, of Research Laboratories of the company.

The invention relates to high-frequency electric induction heating apparatus used for the surface hardening of steel by heating and quenching. The drawing shows an inductor element formed of a split ring *A* of metal, such as copper. High-frequency current is fed to the inductor element by fins *B* joined to the inductor element at the ends on either side of slit *E*. The outer ends of the fins are joined to the ends of a split cylinder *D*, which may also be of copper and which forms the secondary winding of a transformer by means of which high-frequency electric currents are supplied to the inductor element. As shown in the right-hand view, the axial length of the inductor element is appreciably less than the axial length of the cylinder *D*, so that the current is concentrated in the inductor element. Owing to the presence of the slit *E* in the inductor element *A* there is a local reduction in the intensity of heating of a bar of material passing through the inductor element in the region of the slit and this non-uniformity of the heating of the bar may cause distortion. The shape of the inductor element is modified by forming a slot *F* opposite to the slit *E*. The slot *F* extends through part of the radial thickness of the inductor element and extends over the full axial length of the



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inductor element. The dimensions of the slot *F* and, in particular, the width and depth are so chosen as to provide a disturbance in the magnetic field produced at that region similar to that produced by the slit *E*. It is not essential that the slot *F* should be of the same circumferential width as the slit *E*. A modified design in which the inductor element is disposed outside the split cylinder is also shown in the specification.—*November* 12, 1952.

SHAFT GLANDS AND SEALS

687,430. July 24, 1950.—SHAFT SEALS, Difag Fabrik für Dichtungen and Metalldrückerei A.G., Schleifetobelweg 24, Horgen, Switzerland.

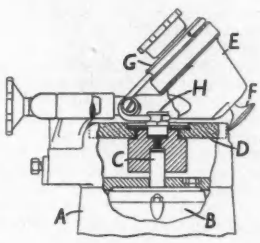
The drawing shows a shaft and a machine part *A* with the seal in position. The part is bored and countersunk at *B* and *C* for housing the seal. This seal comprises an annular casing *D* of sheet metal or plastic material. The end of the casing is shaped as a socket E, which extends inwards and surrounds the shaft. The outer surface of the seal casing is spherical so that it can be made a press fit into the cavity. On the socket a rubber collar *F* is mounted and is held in position by a clamping ring *G*. The rubber collar extends inside the casing and its free end bears with sealing contact on the shaft. To improve the grip the surface of the collar is corrugated. Close to the free end and adjacent to the rim is mounted the spring ring *H*, which increases the pressure on the free end of the collar. There are six forms of seals shown in the specification.—*February* 11, 1953.

No. 687,430

WORKSHOP TOOLS AND APPLIANCES

687,179. October 10, 1950.—GRINDING OR REFACING VALVES, Luke Anthony, Ltd., Rosewarne Road, Camborne, Cornwall. (*Inventor: John Frank Horler.*)

As shown in the drawing, the apparatus comprises a casing *A* housing an electric motor *B*, the shaft *C* of which is connected with and drives a horizontal grinding wheel *D* with a vertical working face. A casing *E* adjacent to the grinding wheel houses a



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rotatable chuck holding a valve *F* at a fixed angle relative to the axis of the wheel. The chuck is driven by a belt, which passes over a pulley *G* on the chuck and a pulley *H* which screws into a carrier disc, rotated by the electric motor. The driving arrangement of the chuck and grinding wheel is described in another specification, No. 687,178. Wheel dressing attachments are also described and illustrated in the specification.—*February* 11, 1953.

Technical Reports

The Design, Construction and Performance of a New High-Speed Cathode-Ray Oscillograph for Recording High-Voltage Surges. By E. L. White, B.Sc. (Eng.), A.M.I.E.E. The British Electrical and Allied Industries Research Association (Ref. S/T70). Price 12s., postage 3d.—The inherently large dimensions of high-voltage circuits impose limitations on accuracy in oscillographic measurements of high-frequency phenomena. These circuit limitations greatly outweigh those of the cathode-ray tube itself. For this class of measurement the modern sealed-off cathode-ray tube has many advantages over the conventional continuously-evacuated oscillograph. This report describes in detail the design of a high-speed cathode-ray oscillograph for recording high-voltage surges, primarily for use in conjunction with a multi-stage surge generator. Operation of the instrument is initiated by a thyratron-controlled tripping circuit with an overall delay of the order of $5 \cdot 10^{-8}$ sec. The cathode beam is swept across the screen by a single-stroke hard-valve sweep circuit in times varying from about 0·2 microsec to 300 microsec. A nearly rectangular pulse derived from the sweep circuit is applied to the modulating grid of the cathode-ray tube to initiate the beam and maintain it at constant current for the duration of the sweep.

Factors Influencing the Creep Resistance of Wrought Carbon Steels. The British Electrical and Allied Industries Research Association (Ref. J/T151). Price 21s., postage 5d.—This report summarises the work on the creep properties of carbon steels carried out for the E.R.A. at the National Physical Laboratory between 1929 and 1948. It includes a discussion on the influence of a number of manufacturing variables and other metallurgical factors on the creep rate, with particular reference to steels having abnormally high creep rates. Special attention is given to the general relationship of grain size to heat treatment and creep resistance.

Flameproof Electrical Apparatus: Flanged Joints, 1in and ¼in in Radial Breadth, in Atmospheres of Heptane-Vapour and Air. By H. Robinson and H. L. Williams. The British Electrical and Allied Industries Research Association (Ref. G/T267). Price 10s., postage 3d.—Particulars of the performance of flanged joints 1in in breadth have been given in a number of reports covering various inflammable mixtures met with in industry and summarised in Refs. G/T139, 167, 183 and 244, and the results formed the basis of the permissible safe gaps prescribed in B.S. 229 : 1946. Attention has now been directed to obtaining similar data for flanges ¼in in breadth, and the present report deals with the case of heptane-vapour and air. The work was carried out by the S.M.R. Establishment of the Ministry of Fuel and Power.

Reactions Between Aggregates and Cement. Part II : *Alkali Aggregate Interaction: British Portland Cements and British Aggregates.* No. 15, National Building Studies Research Papers, D.S.I.R. H.M. Stationery Office. Price 1s.—This paper is the second of a series dealing with chemical reactions between aggregates and cement. Serious breakdowns in concrete structures were first attributed to this cause more than ten years ago in America, and since then similar failures have been recorded in many parts of the world. Although no failures caused by cement aggregate interaction are known to have occurred in this country, the causes and effects of such interaction have been closely studied here. The most serious of these reactions is that between siliceous aggregates and the sodium and potassium hydroxides released during the hydration of the cement. The concrete can be cracked by the swelling of the alkali silicate gel formed in this way. The paper describes measurements of the alkali content of British Portland cements and gives, in a series of tables, data on the percentage of alkalies extracted. Some suggested methods of reducing the alkali content of cements are discussed. The second part of the paper surveys the principal British aggregates from the point of view of possible reactivity with such cements. In this country, flints, malmstones and acid or intermediate volcanic types of rock are the most likely sources of reactive material. It is concluded, however, that there is no reason to expect trouble with the normal British aggregates. Where large concrete structures may be involved it would be wise to examine new sources of aggregate for possible reactivity.

Fuel Cells: A Non-Technical Outline of their Development. By A. P. Paton, B.Sc., A.M.I.Mech.E., A.M.I.E.E. The British Electrical and Allied Industries Research Association (Ref. Z/T89). Price 4s. 6d., postage 3d.—In view of the increasing general interest in fuel cells, this report gives a brief account of research on the subject and the present state of development. Investigations in this country, by the E.R.A. and B.E.A. as well as at King's College, London, are described. Improvements originating in America are also mentioned.

Forthcoming Engagements

Secretaries of Institutions, Societies, &c., desirous of having notices of meetings inserted in this column, are requested to note that, in order to make sure of their insertion, the necessary information should reach this office on, or before, the morning of the Monday of the week preceding the meetings. In all cases the TIME *and* PLACE *at which the meeting is to be held should be clearly stated.*

ASSOCIATION OF SUPERVISING ELECTRICAL ENGINEERS

To-day, March 6th.—LIVERPOOL BRANCH : Liverpool Engineering Society, 9, The Temple, Dale Street, Liverpool, 2, "The Effect of Electric Shock on Humans," D. A. Picken, 7.30 p.m.

Mon., March 9th.—N.W. LONDON BRANCH : Prince of Wales Hotel, Kingsbury, London, N.W.9, "Motor Control Gear," R. F. Mathieson, 8 p.m.

Tues., March 10th.—BOLTON BRANCH : Balmoral Hotel, Bradshawgate, Bolton, "Light and Vision," A. Wilcock, 7.30 p.m.

Wed., March 11th.—BRADFORD BRANCH : Midland Hotel, Bradford, "Lift Control Gear," Mr. Greenwood, 7.30 p.m.

Fri., March 13th.—CREWE BRANCH : Royal Hotel, Nantwich Road, Crewe, "Modern Domestic Electrical Installations," R. Q. Nicholls, 7.30 p.m.

BRITISH [INSTITUTION] OF RADIO ENGINEERS

Tues., March 10th.—LONDON SECTION : School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, W.C.1, Discussion on "The Standardisation of Symbols and the Arrangement of Electronic Circuit Diagrams," opened by L. H. Bainbridge-Bell, 6.30 p.m.

Wed., March 11th.—N.E. SECTION : Institute of Mining and Mechanical Engineers, Neville Hall, Westgate Road, Newcastle upon Tyne, "Slotted Aerial Design," 6 p.m.

CHEMICAL SOCIETY

Thurs., March 19th.—NERNST MEMORIAL LECTURE : Burlington House, Piccadilly, London, W.1, J. R. Partington, 7.30 p.m.

ENGINEERS' GUILD

Fri., March 13th.—W. MIDLANDS BRANCH : Station Hotel, Stafford, Informal Meeting to discuss the formation of a Centre at Stafford, 6.30 p.m.

Thurs., March 19th.—METROPOLITAN BRANCH : Caxton Hall, Caxton Street, Westminster, S.W.1, Debate, "That this House deplores the reasons for the Architectural profession enjoying a higher status than that of the Engineering profession," 6 p.m.

HULL CHEMICAL AND ENGINEERING SOCIETY

Tues., March 10th.—JOINT MEETING WITH HULL GUILD OF BUILDING : Church Institute, Albion Street, Hull, Film, "Strength Where You Need It," N. G. McCullagh, 7.30 p.m.

ILLUMINATING ENGINEERING SOCIETY

To-day, March 6th.—BATH AND BRISTOL CENTRE : S.W. Electricity Board Lecture Theatre, Colston Avenue, Bristol, "Outdoor Illumination," H. A. Turner, 5.30 p.m.

Mon., March 9th.—SHEFFIELD CENTRE : Medical Library, The University, Western Bank, Sheffield, "Road Vehicle Lighting," J. Nelson, 6.30 p.m.

Tues., March 10th.—SESSIONAL MEETING : Royal Society of Arts, John Adam Street, Adelphi, London, W.C.2, Discussion on Post-War Building Studies No. 30, "The Lighting of Office Buildings," 6 p.m.

Wed., March 11th.—HUDDERSFIELD GROUP : Electricity Showroom, Market Street, Huddersfield, "Light and Other Radiations in Crime Investigation," C. H. Edlin, 7.15 p.m.

Thurs., March 12th.—MANCHESTER CENTRE : N.W. Electricity Board, Town Hall Extension, Manchester, "Transport Lighting," E. G. Wotton, 6 p.m.——BIRMINGHAM CENTRE : "Regent House," St. Philip's Place, Colmore Row, Birmingham, Annual General Meeting, 6 p.m.

INSTITUTE OF ECONOMIC ENGINEERING

Fri., March 13th.—Cowdray Hall, Henrietta Place, Cavendish Square, London, W.1, "Management in Action," G. P. E. Howard, 7 p.m.

INSTITUTE OF MARINE ENGINEERS

Tues., March 10th.—85, Minories, London, E.C.3, "Improvements in Ship Performance," J. F. Allen, 5.30 p.m

INSTITUTE OF PETROLEUM

Wed., March 11th.—26, Portland Place, London, W.1, "The International Labour Office and the Petroleum Industry," T. T. Scott, 5.30 p.m.

INSTITUTE OF ROAD TRANSPORT ENGINEERS

Tues., March 10th.—MIDLANDS CENTRE : Crown Inn, Broad Street, Birmingham, "Vehicle Development in the Past Decade," W. C. Wilson, 7.30 p.m.

Wed., March 11th.—E. MIDLANDS CENTRE : Mechanics Institute, Nottingham, "Some Factors Influencing the Choice of Crankcase Lubricating Oil," A. Towle, 7.30 p.m.

Thurs., March 12th.—WESTERN CENTRE : Grand Hotel, Bristol, "The Costing of Vehicle Maintenance," H. Rossington, 7.30 p.m.

Fri., March 13th.—S. WALES GROUP : S. Wales Institute of Engineers, Park Place, Cardiff, "Plastics and Their Use in the Motor Industry," A. Jones, 7 p.m.

INSTITUTE OF WELDING

Mon., March 9th.—SHEFFIELD BRANCH : College of Commerce and Technology, Pond Street, Sheffield, 1, Brains Trust, 7.15 p.m.

Tues., March 10th.—LIVERPOOL BRANCH : 9, Whitechapel, Liverpool, "The Welder and Working Conditions," H. E. Poole, 7 p.m.

Thurs., March 12th.—S. LONDON BRANCH : Messrs. Creed and Co., Ltd., East Croydon, "Welding Jigs and Fixtures for Production and Railway Rolling Stock," P. J. Henneker, 7 p.m. ——JOINT MEETING WITH THE INSTITUTION OF STRUCTURAL ENGINEERS, 11, Upper Belgrave Street, London, S.W.1, "Construction of the New Testing Laboratory of the British Welding Research Association at Abington," E. M. Lewis, 6 p.m.

Fri., March 13th.—S.W. BRANCH : Radiant House, Colston Street, Bristol, "Setting Up, Holding and Positioning for Manual and Automatic Arc Welding," D. Ross, 7 p.m.—— BIRMINGHAM BRANCH : James Watt Memorial Institute, Great Charles Street, Birmingham, Film, "Hardsurfacing," 7 p.m. ——E. MIDLANDS BRANCH : Technical College, Lincoln, "Developments in Welding Research," H. G. Taylor, 7.15 p.m.

INSTITUTION OF CIVIL ENGINEERS

Tues., March 10th.—MARITIME MEETING : Great George Street, London, S.W.1, "Port of London Authority Engineering Works, 1952," G. A. Wilson, 5.30 p.m.

Thurs., March 12th.—MIDLANDS ASSOCIATION : James Watt Memorial Institute, Great Charles Street, Birmingham, "Claerwen Dam : Design and Construction of a 200ft High Gravity Dam for Birmingham Water Department," P. A. Scott, R. J. C. Walton and R. H. Falkiner ,6 p.m.

INSTITUTION OF ELECTRICAL ENGINEERS

Mon., March 9th.—INFORMAL MEETING : Savoy Place, London, W.C.2, Discussion on "Is the Presentation of Technical Literature Adequate ?" opened by M. G. Say, 5.30 p.m.

Wed., March 11th.—RADIO SECTION : Savoy Place, London, W.C.2, "Low-Level Modulation Vision Transmitters with special reference to the Kirk O'Shotts and Wenvoe Stations," E. McP. Leyton, E. A. Nind and W. S. Percival, 5.30 p.m.—— N. SCOTLAND SUB-CENTRE : Caledonian Hotel, Aberdeen, "The Design of High-Speed Salient Pole A.C. Generators for Water Power Plant," H. Johnson and C. P. Holder, 7.30 p.m. ——N. MIDLAND CENTRE : Stafford Arms Hotel, Wakefield, "Electricity Supply : A Statistical Approach to Some Particular Problems," R. B. Rowson, 7 p.m.

Thurs., March 12th.—N. SCOTLAND SUB-CENTRE : Royal Hotel, Dundee, "The Design of High-speed Salient Pole A.C. Generators for Water Power Plant," H. Johnson and C. P. Holder, 7 p.m.

INSTITUTION OF ENGINEERING INSPECTION

Wed., March 11th.—LEEDS BRANCH : Church Institute, Albion Place, Leeds, 1, Film Show, 7.30 p.m.

INSTITUTION OF ENGINEERS AND SHIPBUILDERS IN SCOTLAND

Tues., March 10th.—39, Elmbank Crescent, Glasgow, "Resistance of Single-Screw Coasters, Part I, $L/B=6$," J. Dawson, 7.45 p.m.

Fri., March 13th.—JOINT MEETING WITH DUNDEE INSTITUTE OF ENGINEERS : Engineering Department, University College, Dundee, "Inspection Problems in the Manufacture of Modern Jet Engines," C. Garside, 7.15 p.m.

INSTITUTION OF MECHANICAL ENGINEERS

To-day, March 6th.—GENERAL MEETING arranged in conjunction with the STEAM GROUP : Storey's Gate, St. James's Park, London, S.W.1, series of papers from the Parsons and Marine Engineering Turbine Research and Development Association, dealing with Steam Turbine Research and Development Work carried out at its Research Station, 10.30 a.m., 2.30 p.m. and 5.30 p.m.——N.E. BRANCH, GRADUATES' SECTION : Northern Gas Board Showrooms, Grainger Street, Newcastle upon Tyne, Annual General Meeting, "Significant Changes in Trades Union Outlook Over the Last Decade," D. Russell, 7 p.m.

Tues., March 10th.—AUTOMOBILE DIVISION, GENERAL MEETING : Storey's Gate, St. James's Park, London, S.W.1, "Engineering Changes," Harold Drew, 5.30 p.m.

Fri., March 13th.—GENERAL MEETING : Storey's Gate, St. James's Park, London, S.W.1, "Steels for Steam Power Plant," a Review of Work of a Sub-Committee of the British Electrical and Allied Industries Research Association between 1930 and 1951, compiled by A. M. Sage, 5.30 p.m.

INSTITUTION OF PRODUCTION ENGINEERS

To-day, March 6th.—SOUTHERN SECTION : Polygon Hotel, Southampton, Annual General Meeting, 7 p.m.——W. WALES SECTION : Central Library, Alexandra Road, Swansea, "The Development of Sheet and Tinplate Mills: The Function of Lubricants and Process Oils," W. Williams, 7.30 p.m.

Mon., March 9th.—SHEFFIELD SECTION : Grand Hotel, Sheffield, "Preventive Maintenance," O. Lewis, preceded by Annual General Meeting, 6.30 p.m.——YORKSHIRE SECTION : Hotel Metropole, King Street, Leeds, 1, "Methods of Achieving More Economical Production," D. H. Turnbull, L. Rigg and H. Crompton, preceded by Annual General Meeting, 7 p.m.

Tues., March 10th.—DUNDEE SECTION : Queen's Hotel, Dundee, "Case Hardening and Induction Hardening," W. J. G. Cosgrave, 7.30 p.m.

Wed., March 11th.—BIRMINGHAM SECTION : Cadena Cafe, Worcester, "Materials Handling for Batch Production," F. E. Rattlidge, 7 p.m.——HALIFAX SECTION : George Hotel, Huddersfield, "The Engineering Potentialities of Spheroidal Graphite Cast Iron," A. B. Everest, 7.15 p.m.——PRESTON SECTION : Victoria and Station Hotel, Fishergate, Preston, "Organisation of Production and Planning," B. E. Stokes, 7.15 p.m.

Thurs., March 12th.—LONDON SECTION : Creed and Co., Ltd., Telegraph House, Colston Road entrance, Near East Croydon Station, Surrey, "Welding Jigs and Fixtures for Production of Railway Rolling Stock," P. J. Henneker, 7 p.m.

Fri., March 13th.—EASTERN COUNTIES SECTION : Public Library, Ipswich, Annual General Meeting, "A Machine Tool Symposium," S. L. Cook, R. H. Revett, E. S. Marriott, J. Harper and L. A. Childs, 6.30 p.m.——WESTERN SECTION : Wheatstone Hall, Brunswick Road, Gloucester, "The Activities of the Production Engineering Research Association," D. F. Galloway, 7.15 p.m.

INSTITUTION OF STRUCTURAL ENGINEERS

Thurs., March 12th.—11, Upper Belgrave Street, London, S.W.1, "Construction of the New Testing Laboratory of the British Welding Research Association at Abington," E. M. Lewis, 6 p.m.

JUNIOR INSTITUTION OF ENGINEERS

To-day, March 6th.—Townsend House, Greycoat Place, London, S.W.1, Film Evening, "Highlights of Farnborough, 1952," and "Fire Power and Octane," 7 p.m.

Mon., March 9th.—SHEFFIELD AND DISTRICT SECTION : Livesey Clegg House, Sheffield, "Colour Psychology as Applied to Industry," J. L. Brooke, 7.30 p.m.

Fri., March 13th.—Townsend House, Greycoat Place, London, S.W.1, "Electronic Components : The Elements of an Industry," J. D. Hinchcliff, 7 p.m.

LIVERPOOL METALLURGICAL SOCIETY

Thurs., March 12th.—Liverpool Engineering Society, The Temple, Dale Street, Liverpool, "The Use of Aluminium in Shipbuilding and Structural Engineering," E. G. West, 7 p.m.

NORTH-EAST COAST INSTITUTION OF ENGINEERS AND SHIPBUILDERS

Fri., March 13th.—Mining Institute, Newcastle upon Tyne, "The Use of Heavy Fuels in Diesel Engines of Marine Auxiliary Sizes," J. Smith, 6.15 p.m.

ROYAL SOCIETY OF ARTS

Wed., March 11th.—John Adam Street, Adelphi, London, W.C.2, "The High Paddington Scheme," Sergei Kadleigh, 2.30 p.m.